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COAL AND THE ENVIRONMENT
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Mine Drainage Bibliography 1910-1976

by

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Monroeville, Pennsylvania 15146

Grant 803189

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The Coal Mine Drainage Bibliography covers the following areas: surface and underground mines, active and abandoned mines, reclaimed surface mines, and planning of new mines. Also included are information on lakes formed by surface mining, drainage from coal refuse disposal areas, and water from coal preparation plants. A large number of items are concerned with effects of mine drainage on rivers and streams. In addition to the abstracts, this volume includes an Author Index and a General Index.

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

The Coal Mine Drainage Bibliography has been published by Bituminous Coal Research, Inc. and the Commonwealth of Pennsylvania since 1961. This volume brings together the first eleven issues into a single easier to handle volume. The subject areas of material listed in the bibliography cover surface and underground mines, active and abandoned mines, reclaimed surface mines, and planning of new mines. Also included are information on lakes formed by surface mining, drainage from coal refuse disposal areas, and water from coal preparation plants. A large number of items are concerned with effect of mine drainage on rivers and streams.

This volume should be a valuable reference source for anyone seeking information on mine drainage including the researcher, control agency, 208 planner, industrial planner and preparer of environmental impact studies. For further information contact the Resource Extraction and Handling Division.

David G. Stephan
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Cincinnati

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PREFACE

Work on solving the water pollution problems associated with coal mining has been conducted by numerous public and private institutions since shortly after the turn of the century. As a result of these activities, a large body of knowledge has been developed on the causes, effects, and control of coal mine drainage. Although treatment and abatement methods have been developed, they are not uniformly successful, and coal mine drainage pollution cannot be considered a problem of the past. Additional technology and knowledge must become available but should build upon and not repeat past work. To accomplish this, studies already completed must be readily available. This Coal Mine Drainage Bibliography is the result of this concern with making available such information on coal mine drainage.

In 1961, a special Mine Drainage Library was established at Bituminous Coal Research, Inc., by the Coal Industry Advisory Committee (CIAC) to the Ohio River Valley Water Sanitation Commission. Since then, additions to the collection have been made continuously to keep it current with the latest research and studies in the field. These additions include government reports, scholarly papers in scientific journals, meeting records, symposium proceedings, articles in trade magazines, and reports by the coal industry. In 1964, a bibliography of abstracts of the material in the Mine Drainage Library was prepared by BCR for publication by the Commonwealth of Pennsylvania. Annually through 1974, the Commonwealth continued its support of the preparation of Supplements to the Abstract Bibliography.

This new bibliography has been prepared by BCR with sponsorship of the Pennsylvania Department of Environmental Resources and the United States Environmental Protection Agency. This volume will be significantly easier to handle than the eleven separate issues which had become an unwieldly reference tool. Entries from the previously published Mine Drainage Abstracts which are directly related to water pollution resulting from mining and preparation of coal are repeated here. In addition, this volume has been updated with the inclusion of literature from 1975 and 1976 and also with newly acquired items published earlier but not previously listed in the bibliographies.

The subject areas of material listed in the bibliography cover surface and underground mines, active and abandoned mines, reclaimed surface mines, and planning of new mines. Also included are information on lakes formed by surface mining, drainage from coal refuse disposal areas, and water from coal preparation plants. A large number of items are concerned with effects of mine drainage on rivers and streams.

In addition to the abstracts, this volume includes an Author Index and a General Index, described in the section "The Bibliography, Its Format and Use" beginning on page vii.

Much of the literature abstracted here is available from large libraries, government agencies issuing particular reports, or from the authors. Complete citations have been given so that the reader can obtain material from these sources. Items with NTIS numbers at the end of the citation may be purchased from U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. For those who have difficulty in obtaining material from these sources, arrangements can be made to use the collection at the BCR library on weekdays between 8:00 a.m. and 4:30 p.m. Limited interlibrary loan service and photocopies of non-copyright material for a nominal fee are also available. Please direct requests to Librarian, Bituminous Coal Research, Inc., 350 Hochberg Road, Monroeville, Pennsylvania 15146.

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Searching for and acquisition of mine drainage information is a continuing project. Coverage of the early literature is essentially complete. However, we recognize that, particularly for the most recent years, some material may not have come to our attention. We would appreciate receiving copies of any publications not listed here. Abstracts of previously unlisted material as well as of new publications will be included in future issues of the Bibliography. Any other suggestions, comments or criticism of this publication are welcomed.

FORMAT AND USE OF THE BIBLIOGRAPHY

The abstracts are grouped according to the year of publication with each section being headed by its chronological designation. Within each group abstracts are arranged alphabetically by the first author or, if none, by title. Each abstract is numbered sequentially within the year of publication so that it has its own unique number: for example, MD71-23. The letters MD refer to the general subject area of coal mine drainage. The next two digits refer to the year of publication. The number to the right of the hyphen indicates the order in which that abstract is listed within the publication year. These unique numbers are used to reference the abstracts in the indexes. At the end of each abstract is a number preceeded by OR. This is the file number used by the BCR Library.

The Author Index includes the names of all persons who have been listed as authors or editors on any publication. When the organization is shown as the author, it is listed in the General Index. Names beginning with Mc or Mac have been included alphabetically, as spelled, and are not grouped together.

The General Index includes the following categories: names of industry, government, and academic organizations engaged in or sponsoring work relating to coal mine drainage; geographic features such as names of foreign countries, names of states and regions of the United States, and rivers, streams, and lakes; and subject area topics such as mine drainage formation and neutralization processes which are indicated by terminology which is as specific as possible. In all categories, cross-references and supplemental words and phrases are used liberally to facilitate information retrieval. All entries are intermixed in strictly alphabetical order which follows the word-by-word method, with hyphenated words considered as one word.

A difficulty in indexing has resulted from the changes in organization names that have occurred over the years. For example, many functions of the Pennsylvania Department of Mines and Mineral Industries have been absorbed in the Pennsylvania Department of Environmental Resources. Another example is the United States Environmental Protection Agency which has evolved from the Federal Water Quality Administration and its predecessor the Federal Water Pollution Control Administration. No attempt has been made to include these organizational name changes in indexing earlier publications. Therefore, material is indexed only by the name of the organization which was in use when the item was issued.

In the General Index the Federal government agencies are listed by name and are not grouped together under United States. For instance, Geological Survey is an entry under "G" listings and is identified as being part of the U.S. Department of Interior. State agencies are indexed using the name of the state as the initial word of the agency title, thus Ohio Geological Survey.

1910

MD10-1 GERMICIDAL EFFECT OF MINE WATER AND TANNERY WASTES

Engineering Record 61 (16), 533-534 (Apr. 16, 1910). The effects of the two wastes on the bacteria of sewage were studied by Dr. Samuel G. Dixon of the Pennsylvania Department of Health. This article, based on the Bulletin which was issued by the Department, gives the details of the experimental program and reports the conclusion that the wastes, particularly mine drainage, do inhibit the growth of sewage organisms. OR 10-17

MD10-2 THE ACID WATERS OF WESTERN PENNSYLVANIA

Trax, E. C., Eng. Record 62, 371-372 (1910). Also in Eng. News 64, 362-363 (1910). This general discussion of the effect of acidity from mines on Pennsylvania rivers emphasizes the acid condition of the Youghiogheny River. OR 10-1

1913

MD13-1 ACTION OF ACID MINE WATER ON THE INSULATION OF ELECTRIC CONDUCTORS

Clark, H. H. and Ilsley, L. C., U.S. Bur. Mines, Tech. Paper No. 58 (1913). A method for testing the action of acid water on the insulation of electrical conductors is described and test results are given. OR 10-6

1916

MD16-1 CHEMISTRY IN COAL MINING

Blakeley, A. G., Coal Age 10 (8), 296-302 (1916). This discussion of the function of the chemist in coal mining includes the analysis of several mine waters. OR 10-11

MD16-2 A NEW RAW WATER SUPPLY FOR THE CITY OF MCKEESPORT, PENNSYLVANIA

Trax, E. C., J. Am. Water Works Assoc., 947-958 (1916). The background for changing from the Youghiogheny to the Monongahela River for a source of raw water supply for McKeesport is presented. The effect of acid from mine-drainage was an important factor. OR 10-9

MD16-3 THE CHEMISTRY OF MINE WATER

Young, C. M., Coal Age 10, 704-707 (1916). Analyses of several samples of mine water are used to illustrate the wide variation in composition. Lime and soda ash are discussed as neutralizing agents. The possibility of recovering by-products of the neutralization for commercial use is considered. OR 10-12

1917

MD17-1 USE OF MINE WATER AS BOILER FEED

Chance, M., Coal Age 11, 600-601 (1917). Under normal circumstances, the softening of mine water for use as a boiler feed is not recommended. Neutralization with lime allayed corrosion but caused increased incrustation. A double neutralization, first with lime then with soda ash, stopped both corrosion and scaling but caused the boilers to foam badly. OR 10-13

1918

MD18-1 THE POLLUTION OF STREAMS

Sherlock, C. C., Eng. Mining J. 106, 861 (1918). The rights and responsibilities of the mine owner with respect to use of water are discussed and illustrated by

MD18-1 (continued)

quotations from five court decisions. OR 10-14

1921

MD21-1 MINE-WATER NEUTRALIZING PLANT AT CALUMET MINE

Tracy, L. D., Trans. AIME 66, 609-623 (1921). Also published as "Six tons of ferric hydrates secured daily from water at a Connellsville mine," Coal Age 18 (1), 13-16 (1920). The two products of the limestone neutralization plant at the H. C. Frick Coke Co., Mt. Pleasant, Pa. are hydrated iron oxide, which could be marketed for H_2S removal from manufactured gas or as a pigment; and treated water which was used in quenching coke, and with additional treatment, could be used in the plant's boilers. OR 20-4

MD21-2 POLLUTION OF RIVER WATER IN THE PITTSBURGH DISTRICT

Young, C. M., J. Amer. Water Works Assoc. 8, 201-217 (1921). Mines, waste dumps at coal washeries, and other industries all contribute to the acidity of river water in the Pittsburgh district. Sewage discharged into the rivers serves as a neutralizing agent and is precipitated, resulting in a lower putrefaction rate. The acid in the river water causes damage to boilers, to piping, to clothes, and treatment is expensive and inadequate at best. Analyses of discharges from two mines in the Connellsville district show the extent and character of acid mine drainage pollution. OR 20-8

1922

MD22-1 NATURE OF ACID WATER FROM COAL MINES AND THE DETERMINATION OF ACIDITY

Selvig, W. A. and Ratliff, W. C., Ind. Eng. Chem. 14 (2), 125-127 (1922). The composition of mine water and its natural precipitate, "sulfur mud," is presented. Methods for determining free acidity and total acidity are outlined. Since direct titration of acid mine water for sulfuric acid with alkali solutions in the presence of methyl orange gives results that are too high, ferric iron can be reduced before titration and a correction can be made for the hydrolysis of aluminum sulfate in order to obtain more nearly correct data. OR 20-9

1923

MD23-1 POLLUTION OF WATER SUPPLIES BY COAL MINE DRAINAGE

Collins, C. P., Eng. News-Record 91 (16), 638-641 (1923). The serious character of acid mine drainage is reviewed. The relationship between coal mine drainage and rainfall is presented graphically. A sketch of a suggested plant for treating mine drainage with slaked lime is included. OR 20-16

MD23-2 WHAT SHALL BE DONE ABOUT THE GROWING EVIL OF THE POLLUTION OF STREAMS BY MINE DRAINAGE?

Crichton, A. B., Coal Age 23, 447-451 (1923). A review of the proposed laws to protect water supplies is presented. The increasingly acid condition of streams in western Pennsylvania due to the development of the coal industry is discussed. An estimate of the amount of acid drainage into the Ohio River shows that more than a million tons of lime per year would be needed for neutralization. OR 20-17

MD23-3 ACID-RESISTING ALLOYS FOR USE IN MINE WATER

Enos, G. M., Coal Age 23 (17), 665-668 (1923). A number of materials were subjected to tests in acid mine water and rated for their resistance to corrosion. The analyses of the three western Pennsylvania mine drainages used are given. OR 20-14

1926

MD26-1 RELATION OF DRAINAGE FROM MINES TO STREAM POLLUTION

Crichton, A. B., Mining Congr. J. 12, 418-420 (1926). There is no known satisfactory solution to the acid mine drainage problem. The cost of neutralization would be from 34 to 57 cents a ton, the cost of softening would be from 70 cents to one dollar per ton and even then the water would not be suitable for all uses. There is a real need for a careful investigation of the whole problem before the passage of legislation which would hurt mining or industry. OR 20-18

MD26-2 MINE-WATER PURIFICATION

Handy, J. O., Mining Congr. J. 12, 421-423 (1926). The characteristics of acid mine drainage are discussed. The cost of hydrated lime treatment with a mechanical lime proportioning and feeding device is computed. Prof. James Withrow of the Dept. of Chemical Engineering at Ohio State University discusses the paper. OR 20-20

1927

MD27-1 DISPOSAL OF DRAINAGE FROM COAL MINES

Crichton, A. B., Proc. Amer. Soc. Civil Eng. 53, 1656-1666 (1927). This review of acid mine drainage covers many phases of the problem and includes tabulations of analyses of a number of mine waters and streams in Pennsylvania. Results of lime treatment of drainage at the Melcroft Coal Company are also reported. OR 20-24

1928

MD28-1 OBSERVATIONS OF ACID MINE DRAINAGE IN WESTERN PENNSYLVANIA

Leitch, R. D., Mining Congr. J. 14, 835-839, 848 (1928). Types of mines and coal formations are discussed in relation to coal districts. The quality of water from working and abandoned mines and gob piles and the effect of acid on streams are discussed. The potentiality of neutralization as a control measure is outlined. OR 20-25

MD28-2 A COMPARISON OF THE ACIDITY OF WATERS FROM SOME ACTIVE AND ABANDONED MINES

Leitch, R. D. and Yant, W. P., U.S. Bur. Mines, RI 2892 (1928). 8 pp. In order to determine whether acidity of drainage water from abandoned mines was lower than from active mines, a study was made of active and abandoned mines in the Lower Kittanning bed and in the Upper Freeport bed. The acidity and dissolved oxygen were generally lower in the abandoned mines, most of which were caved, indicating that sealing abandoned mines might further reduce acidity of mine drainage. OR 20-28

MD28-3 PROCESS AND APPARATUS FOR TREATING POLLUTED ACID WASTES: TREATMENT OF POLLUTED WATERS

Travers, J. T. (to Travers-Lewis Process Corp.), U.S. Pat. 1,685,300 (Sept. 25, 1928). 6 pp; U.S. Pat. 1,685,301 (Sept. 25, 1928). 1 p. These are related patents on the treatment of acid wastes. The wastes are passed over a porous calcium carbonate such as travertine and, if necessary, further treated with lime in order to neutralize the acidity and decrease the amount of iron in the waste water. OR 20-29

1929

MD29-1 THE BLENDING OF PIT WATERS

Ridley, C. N., Colliery Eng. 6 (62), 128, 147 (1929). The treatment of mine waters to make them suitable for boiler use can sometimes be accomplished by analysis and

MD29-1 (continued)

blending of various types (hard, alkaline, acid). Some typical analyses are presented. OR 20-27

1930

MD30-1 WANTED: MORE RESEARCH ON ACID MINE DRAINAGE

Carpenter, L. V., Coal Age 35, 406-408 (1930). This historical review of acid mine-water pollution expounds the need for further study and field treatment work. OR 30-1

MD30-2 DEVELOPMENTS IN THE TREATMENT OF ACID MINE DRAINAGE

Carpenter, L. V. and Davidson, A. H., Proc. Va. Acad. Sci. 4, 93-99 (1930). Mine water treatments discussed include neutralization with a number of agents, dilution, and mine sealing. OR 30-2

MD30-3 STREAM POLLUTION INVESTIGATION IN WEST VIRGINIA

Herndon, L. K., W. Va. Univ., Eng. Expt. Sta., Tech. Bull. No. 3, 68-74 (1930). The condition of the Cheat River Basin is reported on briefly. Among the sources of industrial pollution are some 98 coal mines pouring substantial amounts of acid into the basin. The neutralizing effect of some tannery wastes on the acid river is noted. OR 30-3

MD30-4 SEALING OLD WORKINGS PREVENTS ACID FORMATION AND SAVES PIPES AND STREAMS

Leitch, R. D. and Yant, W. P., Coal Age 35, 78-80 (1930). The sealing of abandoned sections of eight mines in south-western Indiana is described. Five of the mines had acid water in open sections and non-acid water in sealing sections. The other mines had no acid water in either the open or sealed sections. OR 30-4

MD30-5 EFFECT OF SEALING ON ACIDITY OF MINE DRAINAGE

Leitch, R. D., Yant, W. P. and Sayers, R. R., U.S. Bur. Mines, RI 2994 (1930). 11 pp. Samples of water were taken from both open and closed sections of eight mines in southern Indiana. The evidence seems conclusive that sealing of worked-out or abandoned sections of mines results in inhibiting acid formation. "Sealing" must mean make air-tight. OR 30-5

1931

MD31-1 EFFECT OF ACID MINE DRAINAGE ON RIVER WATER SUPPLY

Drake, C. F., J. Amer. Water Works Assoc. 23, 1474-1494 (1931). This review of the problem, and the literature dealing with it, emphasizes the effects of drainage from active mines, abandoned mines, and gob piles in the bituminous coal area of western Pennsylvania. State support in the sealing of abandoned mines is recommended with provision that operators be required to seal mines abandoned in the future. OR 30-11

MD31-2 WATER PURIFICATION PROBLEMS IN MINING AND MANUFACTURING DISTRICTS

Drake, C. F., J. Amer. Water Works Assoc. 23, 1261-1271 (1931). Variability of water quality in streams of western Pennsylvania and the resultant problems for water purification plants are outlined. The paper (pp 1261-5) is then discussed by Mr. E. C. Trax (pp 1266-8) and Mr. H. E. Moses (pp 1268-71). OR 30-10

MD31-3 SURVEY OF THE MINE DRAINAGE IN THE WEST FORK RIVER BASIN

Herndon, L. K., W. Va. Univ., Eng. Expt. Sta., Tech. Bull. No. 4, 115-142 (1931).

MD31-3 (continued)

The results of a survey of drainage from 208 mines in the area are tabulated. Conditions of each of the main tributaries and of the West Fork River itself due to the acid drainage are discussed. OR 30-12

MD31-4 THE ACIDITY OF BENNETT BRANCH OF SINNEMAHONING CREEK, PA., DURING LOW WATER - 1930

Leitch, R. D., U.S. Bur. Mines, RI 3097 (1931). 6 pp. At a period of extreme low water, the acidity of Bennett Branch shows no definite indications of being much higher than during normal conditions. Methods of measuring stream volume are described. OR 30-14

MD31-5 THE ACIDITY OF BLACK LICK, TWO LICK AND YELLOW CREEKS, PENNSYLVANIA, DURING LOW WATER IN 1930

Leitch, R. D., U.S. Bur. Mines, RI 3102 (1931). 6 pp. The acidity of Black Lick, and its tributaries Two Lick and Yellow Creeks was determined at various points and related to volume. An equilibrium between total and free acidity in streams polluted by mine drainage seems to exist under certain conditions. Ratio appears to be between 2.0 and 2.3 to 1. OR 30-15

MD31-6 THE ACIDITY OF SEVERAL PENNSYLVANIA STREAMS DURING LOW WATER

Leitch, R. D., U.S. Bur. Mines, RI 3119 (1931). 10 pp. Analyses of samples taken from five streams containing mine drainage during normal low water and extreme low water are discussed. Two showed no change in acidity, two showed an increase in acidity, and one a decrease in acidity. OR 30-16

MD31-7 ACIDITY AND HARDNESS DIFFICULTIES AT MONONGAHELA RIVER PLANTS

Morgan, L. S., Eng. News-Record 106, 850 (1931). The increase in mining activity along the Monongahela River poses increasing problems for the public water works located on the river. Some difficulties are: inadequate capacity of chemical-feed equipment; production of abnormal quantities of sludge; inadequate facilities for sludge removal; shortened filter runs; increased cost of treatment; failure to obtain satisfactory reduction in hardness. OR 30-17

1932

MD32-1 THE DISPOSAL OF COAL MINE LIQUID WASTES

Bach, H., "Proc. Third Int. Conf. Bituminous Coal, Nov. 16 to 21, 1931," Vol. II, Pittsburgh: Carnegie Inst. Technol. (1932). pp 924-959. Various treatment methods of drainage from coal mining areas, coal washery water, and drainage from coal refuse piles in Germany are sedimentation, thickening, neutralization and sludge removal. Disposal of liquid wastes from gas manufacture is also considered. In the discussion of the paper, the mine drainage problem in Appalachia and the details of the Indian Creek litigation are described. OR 30-8

MD32-3 PROCESS OF PURIFYING WATER

Kaplan, B. B. (to David B. Reger, Morgantown, W. Va.), U.S. Pat. 1,878,525 (Sept. 20, 1932). 4 pp. A process for purifying mine water and obtaining marketable by-products is proposed. The addition of cyanides - potassium ferrocyanide, barium ferrocyanide or other forms - precipitates Prussian blue from acid mine water. Besides producing a saleable pigment, the mother liquor is free of acid and does not add to the hardness of streams into which it is discharged. OR 30-50

MD32-3 ACIDITY OF DRAINAGE FROM HIGH PYRITIC COAL AREAS IN PENNSYLVANIA

Leitch, R. D., U.S. Bur. Mines, RI 3146 (1932). 15 pp. Drainage from 39 coal mines

MD32-3 (continued)

in seventeen high pyritic areas in Pennsylvania was sampled. Where possible, samples of water, coal, top and bottom strata, and gob material were taken from inside the mines and forms of sulfur in the solid material were determined. In general, drainage from mines in high pyritic areas was found to be more highly acid than from beds of average or low sulfur coals. OR 30-19

MD32-4 CHARACTER OF DRAINAGE FROM MINES IN THE THICK FREEPORT COAL BED, PENNSYLVANIA

Leitch, R. D., Yant, W. P., and Sayers, R. R., U.S. Bur. Mines, RI 3193 (1932). 29 pp. A survey of the composition of the waters from various sections of 15 mines and the total outflow of 18 mines, shows that at the time of this study the general underground drainage was predominantly alkaline. The total outflow of 3 mines that could not be entered was found to be acid. There is a detailed discussion of the findings on samples from these sources. OR 30-20

MD32-5 COAL MINE DRAINAGE DISPOSAL

Stevenson, W. L., "Proc. Third Int. Conf. Bituminous Coal, Nov. 16 to 21, 1931," Vol. II, Pittsburgh: Carnegie Inst. Technol. (1932). pp 912-923. The Indian Creek decision by the Pennsylvania Supreme Court established the priority of public water supply over the use of streams for discharge of waste. As a means of reducing the number of stream miles affected by mine drainage, coal companies diverted mine discharges into impoundments for regulated discharge. Case histories of practice at Pennsylvania mines showed that often acid drainage in impoundments became either markedly less acid or even alkaline. The role of the Sanitary Water Board in mine drainage pollution abatement was discussed. OR 30-55

1933

MD33-1 ACID MINE DRAINAGE FROM BITUMINOUS COAL MINES

Carpenter, L. V. and Herndon, L. K., W. Va. Univ., Eng. Expt. Sta., Res. Bull. 10, (1933). 38 pp. The quantity of acid mine drainage is correlated with the coal vein, acreage exhausted, and rainfall. Experiments on buffering action are cited. The effect of sterilization on the solubility of sulfur is discussed. A series of tests on the effect of acidity on bacteria and B.O.D. are recorded. Experimental data are correlated with operating data from several water works. (From authors' synopsis) OR 30-22

MD33-2 OXIDATION OF PYRITIC SULFUR IN BITUMINOUS COAL

Nelson, H. W., Snow, R. D., and Keyes, D. B., Ind. Eng. Chem. 25, 1355-1358 (1933). In experiments here described, an increase in temperature increases the rate of oxidation of pyritic sulfur to soluble sulfate. By screening a sample of the pulverized coal to several sized fractions and running a series of oxidation experiments on each fraction, the pyritic sulfur in the finer sizes is oxidized at a faster rate than the larger sizes. Experiments made with ferric sulfate added to the coal-water mixture show that this compound assists materially in the oxidation of the pyritic sulfur in the suspended coal. The effect is enhanced by a rise in temperature. A large amount of the pyritic sulfur is removed from the coal during experiments in which a small amount of chlorine gas is added to the air stream passing through the apparatus. The organic sulfur is unaffected by any of the processes mentioned. (From journal abstract) OR 30-23

MD33-3 A QUARTER CENTURY OF PROGRESS IN THE PURIFICATION OF ACID WATERS

Trax, E. C., W. Va. Univ., College Eng., Tech. Bull. No. 6, 5-19 (1933). In this report on acid mine-drainage many facets of the problems, particularly in the use of Monongahela River waters, are reviewed. Some of the possible approaches to treatment are discussed. OR 30-24

1934

MD34-1 LABORATORY CONTROL

Carpenter, L. V. and Pyle, G. R., W. Va. Univ., Tech. Bull. No. 7, 46-51 (1934). Methods of analysis of acid, iron-containing waters are outlined since "seventy-five percent of the water works in West Virginia have to contend with acid waters which contain appreciable quantities of iron, aluminum, and sometimes manganese." OR 30-67

MD34-2 SEALING ABANDONED COAL MINES: A FEDERAL PROJECT TO PROTECT PUBLIC WATER SUPPLIES

Hatch, B. F., Water Works and Sewerage 81 (3), 99-100 (1934). This resume of the extent of the mine-drainage problem in the Ohio Basin and the proposed Federal Mine-Seal Program contains a brief statement of acid formation, and a description and illustration of several proposed methods for sealing as well as a statement of the anticipated results. OR 30-53

MD34-3 STUDIES OF THE MORGANTOWN WATER SUPPLIES, ESPECIALLY THEIR VARIATIONS IN MINERAL CONTENT

Hodge, W. W. and Newton, R., W. Va. Univ., Tech. Bull. No. 7, 52-53 (1934). Since pollution of the Monongahela by industrial wastes and mine drainage affected the water supplies of West Virginia University and the city of Morgantown, a survey was made to find more and better sources of water for them. Feasible sources other than the Monongahela were Tibbs Run and deep wells. Analytical methods and detailed analyses of Monongahela and Tibbs Run waters are given. OR 30-68

MD34-4 MINE SEALING PROGRAM ON OHIO RIVER WATERSHED

Tisdale, E. S. and Lyons, E. W., J. Amer. Water Works Assoc. 26, 1843-1852 (1934). The mine sealing program of the U.S. Public Health Service is discussed in terms of numbers of closures in Ohio, Pennsylvania, and West Virginia after less than a year of activity. OR 30-59

MD34-5 PURIFICATION PROBLEMS RESULTING FROM POLLUTION BY MINE WATER

Trax, E. C., Water Works Eng. 87 (14), 774-775 (1934). Various aspects of the acid-mine drainage problem such as the effectiveness of sealing abandoned mines, progress in the application of basic methods of treatment, and germicidal action of mine water are discussed. The justifiable degree of water purification is also considered. OR 30-27

1935

MD35-1 SEALING OF COAL MINES - WILL REDUCE ACIDITY OF THEIR EFFLUENT WATERS

Leitch, R. D., Coal Age 40, 323-326 (1935). The Federal Mine Sealing Program is discussed. Several types of seals used in the program are presented graphically and their value to the solution of the problem is pointed out. OR 30-56

MD35-2 TREATING BITUMINOUS COAL MINES TO REDUCE ACID MINE DRAINAGE

Paul, J. W., AIME Tech. Paper 628 (1935). 17 pp. A favorable report of the effectiveness of mine sealing under the Federal and State Civil Works Administration is presented. Drawings and pictures of various types of traps used are given. Water quality data are included for discharge from a number of mines. OR 30-57

MD35-3 ACID MINE-DRAINAGE CONTROL ON UPPER OHIO RIVER TRIBUTARIES

Tisdale, E. S. and Lyons, E. W., J. Amer. Water Works Assoc. 27, 1186-1198 (1935). The economic damage done by mine drainage in West Virginia is assessed in terms of

MD-35-3 (continued)

increased cost of construction to locks and dams; damage to locks, dams, and vessels; treatment for boiler purposes; damage to drainage lines, culverts, etc.; damage to recreational areas; damage to agriculture. It is estimated that $1 million annual loss to West Virginia can be attributed to mine drainage. The Public Health Service program of mine sealing is discussed. Some data relating to the effects of the sealing program are presented. OR 30-60

1936

MD36-1 WEST VIRGINIA COAL SEAMS AND THEIR DRAINAGE

Herndon, L. K. and Hodge, W. W., W. Va. Univ., Eng. Expt. Sta., Res. Bull. No. 14 (1936). 25 pp. Information compiled from various sources includes analyses of coal in West Virginia seams; extent of coal seams by counties; total production from these seams through 1931; and acidity of drainages identified by coal seam, watershed, and counties. Mandatory sealing of mines as they become inactive is proposed as a way of reducing the projected amounts of acid drainage. OR 30-29

MD36-2 OHIO RIVER WATER IN THE WHEELING DISTRICT AND ITS TREATMENT FOR USE IN BOILERS

Hodge, W. W. and Niehaus, E. J., W. Va. Univ., Tech. Bull. No. 8, 41-66 (1936). The objectives of this work are: (1) to secure data on the quality of water and its chemical impurities; (2) to determine any seasonal variations or correlations between river flow and chemical properties of the water; and (3) to determine the effects of each successive operation of the treatment plant. Analyses of river water for 1934 are compared in general with analyses made in 1925 and in 1932, and compared in detail with analyses of treated water. The river water seemed to be becoming more acidic. OR 30-71

MD36-3 POLLUTION OF PITTSBURGH'S RIVERS

Holbrook, E. A., The Pa. Eng., 12-13, 19, Oct. 1936. Sewage, mine drainage and industrial waste all contribute to water pollution in Western Pennsylvania. Although mine drainage is a severe pollutant, it does counteract the harmful effects of the raw sewage dumped into the rivers. Water storage reservoirs to dilute low flows are suggested as one way of alleviating the problem. OR 30-62

MD36-4 UNUSUAL DIFFICULTIES IN TREATING MINE WATER

Holy, W. E., W. Va. Univ., Tech. Bull. No. 8, 16-18 (1936). The development of the discharge from a mine for a public water supply is described. The mine water, with a pH of 7.3 and total iron of 1.5 ppm is aerated, treated with lime, settled, filtered, and chlorinated to give a finished water said to have iron completely removed and a pH of 8.4. The greatest difficulties are a characteristic taste and odor, and a high sulfate concentration. OR 30-69

MD36-5 MINE-SEALING PROGRAM TO REDUCE ACID POLLUTION IN STREAMS

Eng. News-Record 116 (2), 42-43 (1936). The mine sealing program of the WPA in the Ohio River Basin is discussed briefly. Two methods of sealing which depend on a masonry wall built just inside the entrance to the mine shaft exclude air from the mines and thus check the formation of sulphuric acid. OR 30-51

MD36-6 WATER POLLUTION CONTROL IN WEST VIRGINIA

Tisdale, E. S., W. Va. Univ., Tech. Bull. No. 8, 126-132 (1936). In this general discussion of water pollution control, Tisdale reports that air sealing of mines reduces acid formation. OR 30-72

1937

MD37-1 SEALING PROJECTS - SHARPLY REDUCE STREAM POLLUTION FROM ABANDONED MINES

Fellows, P. A., Coal Age 42 (4), 158-161 (1937). Over 1000 abandoned mines having 47,000 openings have been sealed to date. Tests before and after sealing show acidity of drainages to be reduced from 50 to more than 90 percent. OR 30-54

MD37-2 EFFECT OF COAL MINE DRAINAGE ON WEST VIRGINIA RIVERS AND WATER SUPPLIES

Hodge, W. W., W. Va. Univ., Eng. Exp. Sta., Tech. Bull. No. 9, 32-58 (1937). Data collected on amounts of drainage and acid production are summarized by coal seam and by watershed. A review of public water supplies of West Virginia communities shows how they are affected by acid drainage. Analyses of samples taken over more than two years are tabulated to show reduction of acidity after mine sealing. OR 30-31

MD37-3 POLLUTION OF STREAMS BY COAL-MINE DRAINAGE - BENEFICIAL EFFECTS OF SEALING ABANDONED MINES

Hodge, W. W., Ind. Eng. Chem. 29, 1048-1055 (1937). In 1932 the acid pollution of the Ohio River was equivalent to more than 3,000,000 tons of concentrated sulfuric acid. A regional program for air sealing abandoned mines was begun in December, 1933, under the supervision of the USPHS in cooperation with the states in the Ohio Basin. Within three years, over 47,000 openings in 13,500 abandoned coal mines have been sealed; reductions in acid produced have been from 25 to over 80 percent. OR 30-36

MD37-4 MINE SEALING REDUCES ACID POLLUTION OF STREAMS IN THE OHIO BASIN

Coal Mining 14 (2), 6-7 (1937). This is a report on mine sealing in Ohio, Pennsylvania, Kentucky, and West Virginia under the WPA, USPHS, U.S. Army Corps of Eng., and U.S. Bureau of Mines. OR 30-33

MD37-5 A SURVEY OF RECENT DEVELOPMENTS IN THE TREATMENT OF INDUSTRIAL WASTES

Rudolfs, W., Sewage Works J. 9, 998-1014 (1937). The treatment of water related to coal mining is a small part of this general review. The use of flocculants in treating coal washery water is noted. OR 30-37

1938

MD38-1 OXIDATION OF PYRITIC SULFUR IN COAL MINES

Burke, S. P. and Downs, R., Trans. AIME 130, 425-444 (1938). Also published as AIME Tech. Publ. 769 (1937). 20 pp. This is an investigation of the reaction mechanism of the oxidation of pyritic sulfur. The experimental procedures are discussed and extensive data on reaction rates are presented. The effect of acid formation on drainage, on the weathering of coal and gob piles, and as an agent contributing to roof falls is discussed. A discussion of the paper is included. OR 30-39

MD38-2 PROGRESS IN MINE SEALING

Chapman, C. L., W. Va. Univ., Eng. Expt. Sta., Tech. Bull. No. 11, 79-85 (1938). The mine sealing program in the Tygart River Basin of West Virginia is discussed in detail. The economics and results of surface sealing of a mine in Preston County are also presented. OR 30-40

MD38-3 MINE SEALING IN MARYLAND

Hall, G. L., Eng. News-Record 120, 713-715 (1938). The extent of the acid mine-

MD38-3 (continued)

drainage problem in Maryland and the results of the sealing program are discussed. OR 30-41

MD38-4 MITIGATION OF TRADE WASTE POLLUTION IN WEST VIRGINIA

Herndon, L. K. and Withrow, J. R., Trans. AIChE 34, 327-352 (1938). The condition of various river basins in West Virginia is discussed. The harmful effects of acid coal mine-drainage on water for industrial and municipal use and the need for cooperation between the state and industry are presented. OR 30-42

MD38-5 THE EFFECT OF COAL MINE DRAINAGE ON WEST VIRGINIA RIVERS AND WATER SUPPLIES

Hodge, W. W., W. Va. Univ., Eng. Expt. Sta., Res. Bull. No. 18 (1938). 30 pp. Data are presented and literature cited which lead the author to conclude that the air-sealing of abandoned mines and entries, diversion of water from mines, and the construction of large flood control dams offer the best methods for assuring the maintenance of satisfactory stream conditions for public water supplies, industrial uses, and the recreational activities and good health of all the people. OR 30-43

MD38-6 THE FLORA AND FAUNA OF SURFACE WATERS POLLUTED BY ACID MINE DRAINAGE

Lackey, J. B., Pub. Health Repts. 53, 1499-1507 (1938). Biological surveys based on the relative abundance of a limited number of easily recognizable acid tolerant species can be used effectively to determine the condition of acid waters. OR 30-44

MD38-7 SOME TESTS OF ACID-RESISTANT PIPE

Leitch, R. D., U.S. Bur. Mines, RI 3426 (1938). 7 pp. A number of kinds of pipe were tested in low, moderate and high acidity mine-drainage areas. The results are tabulated and illustrated. Several lined pipes proved satisfactory after two years service, even at 10,000 ppm total acidity. OR 30-45

MD38-8 SUBSTANTIAL PROGRESS REPORTED IN MINE SEAL PROGRAM

Coal Mining 15 (2), 8-10 (1938). Activity and costs in the WPA mine sealing program between October 1, 1935 and September 1, 1937 are tabulated. Estimates are also made of amounts of acid reduction. OR 30-38

1940

MD40-1 TESTS ON THE EFFECT OF ACID MINE WATERS ON VARIOUS CEMENTS

Leitch, R. D., and Calverley, J. G., U.S. Bur. Mines, RI 3487 (1940). A study was made of tensile strength characteristics of various cements when made with acid mine water of two concentrations. Increase in acidity of mixing water increased tensile strength in aging tests in the laboratory. However, exposure to acid mine water in the field showed a more rapid deterioration of slabs made with high acid mine waters. OR 40-1

MD40-2 RELATION OF WASTE DISPOSAL TO WESTERN PENNSYLVANIA WATER SUPPLIES

Young, C. H., J. Am. Water Works Assoc. 32, 1867-1882 (1940). The effect of such major industries as the steel and bituminous coal industries on the water supply of western Pennsylvania is discussed. Reducing the amounts of mine drainage and industrial wastes discharged to the streams would have a beneficial effect on the costs of purification and on operating problems of the water works. OR 40-2

1941

MD41-1 ACID MINE DRAINAGE STUDIES AT MORGANTOWN, WEST VIRGINIA

U.S. Public Health Serv., Stream Pollution Invest. Sta., 1941. 52 pp.+ The procedures used to determine stream flow and water quality at various points in the neighborhood of Morgantown are described. The study of the effect of mine sealing on water quality was one of the objectives of the program. Separate reports and comments by C. L. Chapman and F. I. Norris, by P.D. Haney, and by R. D. Leitch are included. OR 40-47

MD41-2 WATER PROBLEM IN THE PENNSYLVANIA ANTHRACITE MINING REGION

Ash, S. H., U.S. Bur. Mines, IC 7175 (1941). 11 pp. Tremendous volumes of water accumulate in area mines. Private and governmental activites in preventing inflow and in dewatering the mines are discussed. OR 40-9

1942

MD42-1 ECOLOGICAL SUCCESSION IN A SERIES OF STRIPMINE LAKES IN CENTRAL MISSOURI

Crawford, B. T., M.A. Thesis, Univ. Mo., 1942. 134 pp. A detailed limnological study was made of a graded series of four acid surface mine lakes near Carrington, in Calloway County, in an area which had been mined from 1919-1921. The field studies were carried out monthly from September 1940 through November 1941. Lake A, the most severely polluted, received drainage from coal refuse and had a pH of 2.8-3.0. Lake B had a pH of 3.4-3.8 with runoff mainly from spoil banks and coal veins in the basin. Lake C had a pH mainly between 6.1 and 6.8 and had a small drainage area with few spoil banks. Lake D had a surface pH of 7.2-7.4 and a drainage area of tilled farmland. Information from the field studies included pH, temperature, color, turbidity; results of analyses for dissolved oxygen, calcium, magnesium, sodium, iron (found only in Lake A), potassium, manganese, strontium, ammonia, nitrogen, nitrate, and nitrite; and species and amounts of plankton and bottom fauna. The less acid lakes showed increased turbidity, less mineral content, and greater species diversity, and temperature stratification similar to eutrophic lakes. However, acid lakes contained so many of the few species they did support that the weight of organisms found was greater than the weight of organisms in the less acid lakes. OR 40-89

MD42-4 INVESTIGATION ON TREATMENT AND DISPOSAL OF ACID INDUSTRIAL WASTES

Morgan, L. S., Sewage Works J. 14, 404-409 (1942). The acid mine drainage problem in Pennsylvania and the effect of the mine-sealing program of 1936 are discussed. Analytical data and some suggestions for attacking the acid problem are included. OR 40-13

MD42-3 OHIO RIVER POLLUTION SURVEY - FINAL REPORT TO THE OHIO RIVER COMMITTEE - SUPPLEMENT "C" - ACID MINE DRAINAGE STUDIES

Office of Stream Sanitation, U.S. Public Health Serv., 1942. This survey has been conducted to study the basic theories of acid formation in coal mines and the possibilities and experience with remedial measures. Studies by the U.S. Bureau of Mines have shown that mine sealing can control acid at the mine at reasonable cost. Flood control reservoirs can be used to control acidity in some streams by storage of alkaline water and release as needed. Chemical neutralization has proven impractical due to economic factors. Quality of Allegheny and Monongahela Rivers are shown graphically and discussed. OR 40-11

1943

MD43-1 NOTES ON MINE DRAINAGE STREAM POLLUTION

McElroy, D. L., Presented to Somerset County (Pa.) Coal Operators Assoc., Nov. 3, 1943. 6 pp. The problem of acid mine drainage is presented, followed by discussion of suggested means of eliminating it. OR 40-15

MD43-2 PENNSYLVANIANS HOLD JOINT MEETING

Water Works and Sewerage 90, 395-400 (1943). At a joint meeting of Western Pa. AWWA Section and Western Div. of the Pa. Water Operators Assoc., M. Le Bosquet, Jr., Senior Engineer USPHS, Cincinnati, Ohio and E. W. Lyons, Senior Engineer U.S. Bur. Mines, presented a paper on "Acid mine drainage studies in the Ohio River Pollution Survey." Mine sealing and dilution reservoirs have cut the estimated total annual damage from mine drainage about in half. A discussion of the paper by C. A. Finley, C. H. Young, L. H. Enslow, and C. W. Rice followed. OR 40-14

1945

MD45-1 MINE DRAINAGE PRACTICE IN THE ANTHRACITE REGION OF PENNSYLVANIA

Griffith, E., AIME, Tech. Publ. No. 1907 (1945). 18 pp. This is a discussion of the drainage practices of the anthracite region. Despite efficient pumping layouts, tunnels for draining active mines and large-scale surface-drainage facilities for keeping water out of mines, the anthracite industry is threatened with curtailment of a major degree and premature extinction because of encroachment of water. OR 40-18

MD45-2 INVESTIGATIONS ON COAL MINE DRAINAGE - INTERIM REPORT, JANUARY 1944 TO JULY 1945

Hodge, W. W. and Hinkle, M. E., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Interim Rept., Aug. 1945. 15 pp. The objectives of the program are outlined. Analyses of acid and alkaline mine effluents and of roof drips are presented. Sulfur balls were tested for reactions in water and were examined for changes in air. OR 40-60

1946

MD46-1 FLOOD PREVENTION AND CONTROL IN THE ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H., Mining Congr. J. 32 (3), 32-34, 46 (1946). This is a statement of the water problem in the anthracite mines of Pennsylvania. OR 40-26

MD46-2 BACKFILLING PROBLEM IN THE ANTHRACITE REGION AS IT RELATES TO CONSERVATION OF ANTHRACITE AND PREVENTION OF SUBSIDENCE

Ash, S. H. and Westfield, J., U.S. Bur. Mines, IC 7342 (1946). 18 pp. The risk of inundation of mines in sections of the anthracite region is increased by subsidence of strata overlying mine workings filled with loosely consolidated water bearing materials. This paper discusses backfilling as a possible solution to the subsidence problem. OR 40-23

MD46-3 FLOOD-PREVENTION PROJECTS AT PENNSYLVANIA ANTHRACITE MINES - A PRELIMINARY STUDY

Ash, S. H. and Westfield, J., U.S. Bur. Mines, RI 3868 (1946). 25 pp.+ This report covers work conducted during an investigation of the anthracite mine-flood problem. It describes construction work on four mine flood-prevention projects that offered a field for scientific and technologic studies of the problem. OR 40-21

MD46-4 STREAM POLLUTION: EFFECT OF ACID WASTES ON NATURAL PURIFICATION OF THE SCHUYLKILL RIVER

Chubb, R. S. and Merkel, P. P., Sewage Works J. 18 (4), 692-694 (1946). An acid stream interferes with biochemical decay making it even more important that treatment of organic wastes take place before dumping into the stream. Natural stream purification can operate only when an environment favorable to decay organisms is provided. OR 40-24

MD46-5 INVESTIGATIONS ON COAL MINE DRAINAGE - 1944 ANNUAL REPORT

Hinkle, M. E. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, May 1946. 100 pp.+ The objectives of the Fellowship are: to determine the composition and properties of coal mine drainage waters; to investigate factors causing the formation of acid mine drainage; to develop methods for reducing the quantity of acid mine waters; to develop processes for the recovery of usable by-products; and to improve methods of disposal. The results of the first year of work are primarily in the field of identification and development of methods of analysis. OR 40-62

MD46-6 INVESTIGATIONS ON COAL MINE DRAINAGE - ANNUAL REPORT FOR 1945

Hinkle, M. E. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, June 1946. 29 pp. Studies of methods of analysis of acid mine waters were continued. Nitrogen was found in large amounts in both acid and alkaline mine drainage waters. OR 40-64

MD46-7 INVESTIGATIONS ON COAL MINE DRAINAGE - QUARTERLY REPORT, JULY 1, TO SEPTEMBER 30, 1946

Hinkle, M. E. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Nov. 1946. 14 pp. The investigation of the acid mine drainage problem has been expanded to include a study of abandoned mine atmospheres, waste materials, and organisms present in mines. The chemical analysis methods are under examination to further refine them. OR 40-63

MD46-8 INVESTIGATIONS ON COAL MINE DRAINAGE - SEMI-ANNUAL REPORT FOR THE FIRST HALF OF 1946

Hinkle, M. E. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, July 1946. 13 pp.+ A rapid field method of analyzing acid mine water samples has been devised to give pH and total acidity, sulfuric acid, ferrous and ferric iron, aluminum, manganese, and total sulfates. The effect of hydrolysis of the ferric sulfate on the pH of the solution is further investigated. OR 40-65

MD46-9 TREATMENT OF ACID MINE WATER FOR BREAKER USE IN THE ANTHRACITE REGION OF PENNSYLVANIA

Johnson, L. H., U.S. Bur. Mines, IC 7382 (1946). 14 pp. Mine water with low acid content is used without treatment for breaker use, but in many instances the mine water is highly acid and is treated to protect metals from corroding. A study of lime treatment systems in use was conducted to determine the range and effect of treatment, determine the types of lime in use, correlate the testing procedures, and obtain available cost data. OR 40-22

1947

MD47-1 FLOOD-PREVENTION PROJECTS AT PENNSYLVANIA ANTHRACITE MINES - PROGRESS REPORT FOR 1945

Ash, S. H., Cassap, W. E., Westfield, J., Eaton, W. L., Romischer, W. M., Podgorski, E. J., and Johnson, L. H., U.S. Bur. Mines, RI 4109 (1947). 64 pp. The following

MD47-1 (continued)

subjects are covered in this report: (1) Anthracite reserves of Pennsylvania; (2) Underground Water Pools, giving maps and cross sections of underground water pools and an estimate of quantities of water impounded; (3) Barrier Pillars; (4) the "Buried Valley" of the Susquehanna River with its description of structure and a discussion of its relation to mine water problems; (5) mining subsidence and backfilling; and (6) protective methods utilized to prevent corrosion of equipment by acid mine water; a resume of the durability of materials used in handling acid mine water. OR 40-28

MD47-2 THE ROLE OF MICROORGANISMS IN ACID MINE DRAINAGE. A PRELIMINARY REPORT

Colmer, A. R. and Hinkle, M. E., Science 106, 253-256 (1947). Iron oxidizing and sulfur oxidizing bacteria were isolated from acid mine drainage. The sulfur oxidizing bacterium was similar to Thiobacillus thiooxidans which was shown to be able to grow under conditions characteristic of mine drainage. OR 40-29

MD47-3 INVESTIGATIONS ON COAL MINE DRAINAGE - 1946 ANNUAL REPORT

Hinkle, M. E. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Jan. 1947. 20 pp. A rapid field method of titration, field studies of the materials and mine conditions affecting the acidity of mine water, the influence of organisms on mine water are among the subjects being investigated by this fellowship. The results of a survey to determine if any correlation exists between specific types of sulfur bearing materials in a coal seam and acidity are discussed. OR 40-70

MD47-4 INVESTIGATIONS ON COAL MINE DRAINAGE - SUMMARY REPORT, JANUARY 1944 TO JUNE 1, 1947

Hinkle, M. E. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, May 1947. 32 pp. Work performed from January to June 1947 is covered in the first part of this report. The operation of a miniature mine drainage course; oxidation of coal as a source of CO_2 in coal mine atmosphere; and bacteriological investigations are discussed. The remainder of the report is a summary of all the work done on the project through June 1947. The topics covered are bacteriological investigations; differences in mine waters; difficulties in accurate determination of acidity, including manganese and aluminum which can give false results; development of a field analysis; sulfur containing materials; and formation of mine drainage. OR 40-83

MD47-5 INDUSTRIAL WASTES...ACID MINE DRAINAGE

Hoffert, J. R. (Pa. Dept. Health), Ind. Eng. Chem. 39, 642-646 (1947). The chemistry of mine drainage formation, the effects of acid pollution and attempts to alleviate the problem, particularly by mine sealing, are all discussed. OR 40-90

MD47-6 COAL WASHERY PLANTS

Parton, W. J., Ind. Eng. Chem. 39, 646-652 (1947). The operation of coal cleaning plants and the treatment of washery water are described. Settled waste solids can be processed to recover salable coal fines. OR 40-75

MD47-7 WATER TREATMENT GUIDE

Roetman, E. T., Watson, K. S., and Cotton, E. R., Interstate Comm. Potomac River Basin (1947). 39 pp. Mine waste, including acid mine drainage and coal washery water, is one of the many industrial wastes covered. OR 40-30

MD47-8 EFFECTS OF COAL STRIP MINING UPON WATER SUPPLIES

Snyder, R. H., J. Am. Water Works Assoc. 39, 751-769 (1947). The mechanics of surface mining operations, the chemistry of acid formation from pyrite together with some of the side reactions, and the effect of the acid on fresh-water streams are reviewed. Included is an account of a legal proceeding against coal operators for pollution of water sources because of acidity from surface mines. A discussion of the problem by others points out the inadequacy of present laws, survey methods which may be used, flow computations, and chemical analyses showing the effect of acid pollution. OR 40-36

MD47-9 STREAM POLLUTION CONTROL - HEARINGS

U.S. Senate Comm. Public Works, Subcomm. Flood Control and Improvement of Rivers and Harbors, 80th Congress, 1st Session, April, May 1947. 403 pp. Appearing before the Committee on behalf of the National Coal Association, Mr. Andrew B. Crichton (pp 241-255), Dr. Harold J. Rose (pp 255-267), and Mr. Harry Gandy, Jr. (pp 267-273) all voiced objections to the bill because of its possible harmful effect on the coal industry. Mr. A. C. Fieldner (pp 278-286), representing the Bureau of Mines, spoke for the bill. OR 40-32

1948

MD48-1 FLOOD-PREVENTION PROJECTS AT PENNSYLVANIA ANTHRACITE MINES. PROGRESS REPORT FOR FISCAL YEAR ENDED JUNE 30, 1947

Ash, S. H., Cassap, W. E., Eaton, W. L., Hughes, K., Romischer, W. M., and Westfield, J., U.S. Bur. Mines, RI 4288 (1948). 51 pp. In investigative work conducted by the Anthracite Flood-Prevention Section, Safety Branch, Bureau of Mines, during the period July 1, 1946 to June 30, 1947 data were obtained on anthracite reserves of Pennsylvania; underground water pools; barrier pillars; the buried valley of the Susquehanna River; and the infiltration of surface water into underground mine workings. OR 40-45

MD48-2 ACID MINE WATER IN THE ANTHRACITE REGION OF PENNSYLVANIA

Felegy, E. W., Johnson, L. H., and Westfield, J., U.S. Bur. Mines, Tech. Paper 710 (1948). 49 pp. This initial study of the problem is based on a sampling program carried out in 1941 and 1946 on the Susquehanna, Lackawanna, Lehigh, Schuylkill, and Little Schuylkill Rivers and on mine drainage discharges in the area. Although large volumes of highly acid drainage entered the rivers, they were found to be mainly alkaline because of pollution from sewage and alkaline industrial discharges. The cost of lime neutralization was discussed. OR 40-27

MD48-3 THE TREATMENT OF COAL WASHERY WATER TO AVOID STREAM POLLUTION

Hebley, H. F., Sept. 24, 1948. 7 pp. The methods used by coal preparation plants to reduce the amounts of solids and silt discharged to streams are discussed. OR 40-44

MD48-4 THE ACTION OF CERTAIN MICROORGANISMS IN ACID MINE DRAINAGE

Hinkle, M. E. and Koehler, W. A., AIME, Coal Div., Tech. Publ. 2381 (1948). 5 pp. By means of bacteriological techniques, two organisms have been isolated from acid mine-drainage. These are believed to have a part in promoting the chemical reactions which produce discolored acid mine-drainage. One organism is considered to be Thiobacillus thiooxidans. The other has not been identified but is described as "Gram negative, none-spore forming rods approximately 0.4 micron wide by 0.8 to 1.0 micron long." OR 40-41

MD48-5 OHIO RIVER VALLEY WATER SANITATION COMPACT

1948. 12 pp. This is a copy of the document duly executed by Indiana, West Virginia, Ohio, New York, Illinois, Kentucky, Pennsylvania, and Virginia for the purpose of the control and abatement of pollution of the waters of the Ohio River basin. OR 40-47

MD48-6 PROBLEMS OF MINERAL CONSERVATION

Pa. Dept. Commerce, State Planning Bd. (1948). 40 pp. The problem of mine water is discussed briefly in section 6. Some pictures of streams clogged with coal mine wastes are included. OR 40-46

MD48-7 INVESTIGATIONS ON COAL MINE DRAINAGE - QUARTERLY REPORT, JULY 1 TO SEPTEMBER 30, 1948

Temple, K. L. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Oct. 1948. 8 pp. This report contains further studies on sulfur oxidizing bacteria. OR 40-84

1949

MD49-1 WATER POOLS IN PENNSYLVANIA ANTHRACITE MINES

Ash, S. H., Eaton, W. L., Hughes, K., Romischer, W. M., and Westfield, J., U.S. Bur. Mines, Tech. Paper 727 (1949). The principal factor that threatens to cut short the life of the anthracite industry is inundation of the mines. The information covered in this report was obtained by studying geological maps and cross-sections, mine maps, and other pertinent data obtained by anthracite mining companies. The report includes maps, plans, cross-sections, and longitudinal sections of the underground water pools. OR 40-53

MD49-2 SCIENCE IN THE CONTROL OF WATER-BORNE WASTES

Beal, G. D., Ann. Meet., Ind. Hyg. Found., Pittsburgh, Pa., Nov. 18, 1949. The effect of acid on the self purification of streams is discussed. Steps that should be taken by industrial organizations discharging into streams are outlined in general terms. OR 40-76

MD49-3 MUNICIPAL-WATER NEEDS VS. STRIP COAL MINING

Dexter, G. M., Trans. AIME 184, 137-158 (1949). This paper describes the practice of the Sunnyhill Coal Co., near Pittsburgh, of contouring its surface mined land to bury acid forming material, thus reducing acid drainage onto the watershed which feeds West Penn Water Company reservoirs. Also discussed are the effect of rainfall on contoured and uncontoured land and the extent to which raw mine water needs to be treated for domestic and industrial use. OR 40-54

MD49-4 TRIENNIAL REPORT ON MINE ACID DRAINAGE

Madison, K. M., Mellon Inst., Fellowship No. 326, Rept. to Pa. Dept. Health, Sanit. Water Bd. (1949). 138 pp. In this three year study, the ability for self-purification of streams polluted with mine acid, sewage, and/or industrial wastes is evaluated. Laboratory studies point out that biological oxygen demand techniques do not measure pollution accurately in waters containing iron sulfates. Therefore, a dichromate oxygen demand method was developed and found to be satisfactory. Five drainage areas were surveyed and found to be polluted with sewage as well as mine drainage. Using *Escherichia coli*, mine acid was found to have a bactericidal effect. This indicates that mine drainage would stop self-purifying activities of microorganisms on sewage. Part of the study is concerned with the self-purifying effect of coprecipitation of organic material and iron sludge. Although coprecipitation does occur, it was found that the organic load is carried along either

MD49-4 (continued)

immediately as suspended iron complexes or later as washed out sludge deposits, and that the large rivers must finally oxidize the sewage from acid streams. OR 40-82

MD49-5 OHIO RIVER VALLEY WATER SANITATION COMMISSION-FIRST ANNUAL REPORT 1948-1949

Cincinnati, Ohio (1949). 24 pp. The objectives and accomplishments of the Commission, together with a financial statement and list of people associated with the Commission are presented in this annual report. OR 40-55

MD49-6 INVESTIGATIONS ON COAL MINE DRAINAGE - ANNUAL REPORT, JULY, 1948 TO JULY, 1949

Temple, K. L., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, July 1949. 17 pp.+ The experimental work showing the influence of bacteria in the formation of mine drainage is reported in detail. OR 40-86

MD49-7 INVESTIGATIONS ON COAL MINE DRAINAGE - QUARTERLY REPORT, OCTOBER 1 TO DECEMBER 31, 1948

Temple, K. L. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Jan. 1949. 6 pp. This report is a continuation of perfusion unit experiments with sulfur oxidizing bacteria. OR 40-85

1950

MD50-1 BURIED VALLEY OF THE SUSQUEHANNA RIVER, ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H., U.S. Bur. Mines, Bull. 494 (1950). 27 pp. Buried valleys contain water-bearing irregular deposits of clay, sand, and gravel. Drainage flows from these deposits through any openings into mines below and may become catastrophic. Geological and mining information has been compiled for the buried valley in the drainage basin of the North Branch of the Susquehanna River that overlies the anthracite measures in the Wyoming Valley and the lower part of the Lackawanna Valley. A set of maps accompanies the report. OR 50-22

MD50-2 DATA ON PUMPING AT THE ANTHRACITE MINES OF PENNSYLVANIA

Ash, S. H., Eaton, W. L., Gilbert, J. C., James, H. M., Jenkins, H. E., Kennedy, D. O., Kynor, H. D., Link, H. B., and Romischer, W. M., U.S. Bur. Mines, RI 4700 (1950). 264 pp. The report includes descriptions of types of pumps used, precipitation in the area, and amount of water pumped at a number of collieries from 1944 to 1948. OR 50-20

MD50-3 INUNDATED ANTHRACITE RESERVES, EASTERN MIDDLE FIELD OF PENNSYLVANIA

Ash, S. H., Kynor, H. D., Fatzinger, R. W., Davies, B. A., and Gilbert, J. C., U.S. Bur. Mines, Bull. 491 (1950). 28 pp. An engineering study is necessary to explore the various methods that can be used to unwater anthracite reserves that are now inundated by underground water pools in the various basins in the Eastern Middle fields. Any conclusions relating to projects for unwatering these pools must be based primarily upon the economic justification of each project and the ratio of the cost to the benefit that would result. In this report one major unwatering project was developed. Three pools that inundate considerable tonnage of anthracite reserves are close enough together to be unwatered by some centralized system. Three alternative plans were studied to estimate the cost of each. (From authors' Introduction) OR 50-21

MD50-4 ANNUAL SUMMARY REPORT OF COMMONWEALTH OF PENNSYLVANIA DEPARTMENT OF HEALTH, INDUSTRIAL FELLOWSHIP NO. 4 (Aug. 20, 1949 to Aug. 20, 1950)

Braley, S. A., Mellon Inst., Fellowship No. 362B (1950). 57 pp. This annual report on the work of the project includes data on the amount and character of water discharged and the atmosphere inside six sealed mines as determined by weekly samplings. The data confirmed the earlier reported belief that the pounds of sulfuric acid discharged from a mine is a function of the volume of flow. The effect of discharges from two of the mines on Indian Creek, Pennsylvania is reported. An attempt was made in one mine to neutralize acid by ammonia with no effect. OR 50-40

MD50-5 RECENT RESEARCH AS TO THE EFFECT OF COAL MINE DRAINAGE ON THE CLEAN STREAM PROGRAM

Braley, S. A., Presented to 2nd Ann. Meet., Pa. Sect., Am. Water Works Assoc., Oct. 18-20, 1950. 9 pp. The pH, acidity, total poundage of acid and flow of water from four mines are presented graphically. The basis for neutralization is briefly discussed. OR 50-25

MD50-6 AN IRON OXIDIZING BACTERIUM FROM THE ACID DRAINAGE OF SOME BITUMINOUS COAL MINES

Colmer, A. R., Temple, K. L., and Hinkle, M. E., J. Bacteriol. 59, 317-328 (1950). The morphological character of a bacterium, isolated from the acid mine drainage of the Pittsburgh, Sewickley, and Upper Freeport coal seams, its autotrophic nature on thiosulfate medium, and its oxidative action on thiosulfate with the production of sulfuric acid to give a low pH resemble properties of the genus *Thiobacillus*. Experimental methods and data are given for the action of the bacterium on ferrous iron solutions. OR 50-18

MD50-7 COMMENTS ON STREAM POLLUTION IN PENNSYLVANIA

Hebley, H. F., Unpublished report, 1950. 16 pp. Pennsylvania Sanitary Water Board and its function in stream pollution control in Pennsylvania are described. Methods of treatment for acid mine water drainage are discussed in the light of research on the problem. The mechanism of bacterial action in the formation of acid is outlined. The problems of neutralization of acid with lime are set forth. The objectives and results of the mine sealing program are discussed. OR 50-1

MD50-8 NEUTRALIZING ACID MINE WATER

Hebley, H. F., Mining Congr. J. 36 (8), 62-63 (1950). Neutralization of acid mine water with lime was successful at the Calumet mine of the H. C. Frick Coal Co. only because of the special market for by-product iron hydroxide during World War I. The cost of neutralization and the declining market for the by-product together with the technical problems of treatment make this an unattractive method. Mine sealing and problems associated with surface mining are discussed briefly. OR 50-36

MD50-9 RECENT DEVELOPMENTS IN STREAM POLLUTION ABATEMENT

Hebley, H. F., June 1, 1950. 6 pp. Mr. Hebley discussed the implications of the jurisdiction of the Pennsylvania Sanitary Water Board over water pollution from coal mining. The experimental rules for mining coal by stripping without causing pollution are cited. OR 50-16

MD50-10 ABATING STREAM POLLUTION IN THE ANTHRACITE COAL FIELDS

Hoffert, J. R., Mining Eng. 2, 340-343 (1950). The program of the Pennsylvania Sanitary Water Board to reduce colliery silt in eastern Pennsylvania rivers is described. Colliery operators collected data on which to base requirements and installed desilting devices. OR 50-13

MD50-11 CLEANUP OF A RIVER

Hoffert, J. R., Pittsburgh Equitable Water J. 34 (2), 2-5 (1950). With the advent of the wet preparation of coal, enormous quantities of silt were discharged into the Schuylkill River and its tributaries, choking the channel and causing flooding. As a result of the work of the Sanitary Water Board starting in 1941, desilting works (ranging from sedimentation basins to froth flotation apparatus), were installed at all 43 collieries using water in coal preparation. This water treatment and dredging operations, dam reconstruction, and river bank stabilization program of the Water and Power Resources Board have resulted in a measurable improvement in the river. OR 50-32

MD50-12 SOLVING POLLUTION PROBLEMS IN THE POTOMAC RIVER BASIN

Kemp, H. A., Interstate Comm. Potomac River Basin, Washington, D.C. (1950). 19 pp. The author summarizes the need for, and the steps taken toward, the control and abatement of pollution within the Potomac River basin. He touches on the problems of soil loss, water pollution by industrial, domestic, and mine wastes, sketches briefly the history and aims of the Potomac River Commission, and outlines its program for the future. (From the Foreward) OR 50-31

MD50-13 DEEP-WELL PUMPS AND SHAFT PUMPS IN ANTHRACITE MINES OF PENNSYLVANIA

Lesser, W. H., U.S. Bur. Mines, RI 4656 (1950). 52 pp. The purpose of the report is to furnish data concerning application, design, and performance of deep-well and shaft pumps to the anthracite flood-prevention program for consideration when a pumping project develops that favors the use of these pumps. OR 50-19

MD50-14 POLLUTION IN THE ALLEGHENY, MONONGAHELA AND OHIO RIVERS IN ALLEGHENY COUNTY, PENNSYLVANIA

Madison, K. M., Presented, ACS 118th Natl. Meet., Chicago, Ill., Sept. 5, 1950. 28 pp. The oxygen demand data presented give evidence that the Allegheny, Monongahela, and Ohio Rivers carry significant amounts of organic pollution. The effect of acid mine water on organic wastes in these rivers needs to be considered in reviewing the need for treatment of the river waters. As effective controls of mine water discharge are developed, the need for sewage treatment plants will increase. OR 50-26

MD50-15 OHIO RIVER VALLEY WATER SANITATION COMMISSION - SECOND ANNUAL REPORT

Cincinnati, Ohio, 1950. 42 pp.+ This is a report on the activities of ORSANCO in the second year of its existence. Pages 29-34 deal with the acid mine drainage problem and include a table summarizing the annual damages from acid mine drainage based on 1940 cost and a tabulation of significant court cases relating to stream pollution and the coal mining industry. OR 50-24

MD50-16 REPORT ON INDUSTRIAL WASTES IN THE POTOMAC RIVER BASIN

Interstate Comm. Potomac River Basin, Washington, D.C. (1950). 17 pp. Acid mine drainage is only one of many industrial sources of pollution. Taken as a whole, the industrial reports indicate that much is still to be done by industry to abate pollution, yet there is evidence of a certain awareness of the need for pollution abatement in the Potomac Basin. OR 50-27

MD50-17 INVESTIGATIONS ON COAL MINE DRAINAGE - QUARTERLY REPORT, JANUARY - MARCH 1950

Temple, K. L., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Apr. 1950. 11 pp. Laboratory experiments and field studies of the source of acid in mine drainage associate the minerals copiapite, alunogenite, copperos, and Starkeyite with acid forming areas. In the No. 2 Gas, Upper Freeport, and Pittsburgh

MD50-17 (continued)

seams, acid formation took place in the shales and wild coals above the seam rather than in the coal itself, and occurred only when the roof structure was broken to expose the upper strata. Acid spots always contained sulfur oxidizing bacteria. (From author's Summary) OR 50-34

MD50-18 INVESTIGATIONS ON COAL MINE DRAINAGE - SEMI-ANNUAL REPORT, JULY 1 TO DECEMBER 31, 1949

Temple, K. L. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Jan. 1950. 14 pp. A study of the bacterial oxidation of ferrous iron to ferric iron in mine water containing ferrous sulfate is given in this report. OR 50-41

MD50-19 INVESTIGATIONS ON COAL MINE DRAINAGE - ANNUAL REPORT, JULY 1949 - JULY 1950

Temple, K. L. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, July 1950. 21 pp. A survey of some of the pertinent known facts about acid mine water is given and some ideas about the formation of acid are presented. It appears that acid is formed chiefly from strata overlying the coal and occurs only where the roof structure is disturbed. The changes taking place in the water after ferrous sulfate is formed are discussed. The relationship of bacteria to acid formation is also considered. OR 50-35

MD50-20 STREAM POLLUTION FROM COAL MINES IN THE OHIO BASIN

Watson, K. S., Presented, Joint Meet. W. Va. Coal Mining Inst., and Appalachian Sect. and Coal Div., AIME, Charleston, W. Va., June 16, 1950. 13 pp.+ The range of mine drainage pollution in the Ohio River Basin is outlined. This paper is a part of the Reference Data Series of the Ohio River Valley Water Sanitation Commission. OR 50-17

1951

MD51-1 ACID MINE DRAINAGE PROBLEMS, ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H., Felegy, E. W., Kennedy, D. O., and Miller, P. S., U.S. Bur. Mines, Bull. 508 (1951). 72 pp. This report indicates the scope of the pollution problem associated with mine-water discharge in the anthracite region of Pennsylvania and gives some suggestions, mainly related to diversion concerning its solution. The 327,000 g.p.m. drainage from the mines of the region has an estimated pH of 3.0-3.2. However the alkalinity of the rivers receiving this discharge can offset this acidity at most times. OR 51-4

MD51-2 ACID DRAINAGE FROM COAL MINES

Braley, S. A., Trans. AIME 190, 703-708 (1951). Laboratory results and investigations at four mines are discussed. OR 51-19

MD51-3 A PILOT PLANT STUDY OF THE NEUTRALIZATION OF ACID DRAINAGE FROM BITUMINOUS COAL MINES

Braley, S. A., Pa. Dept. Health, Sanit. Water Bd., 1951. 14 pp. Conclusions from the study are that neutralization of acid mine drainage is possible but not economically feasible; and that prevention of formation by controlled drainage is a more realistic approach to the problem. OR 51-1

MD51-4 COAL MINE DRAINAGE

Pa. Dept. Health, Bur. Sanit. Eng., Bull. No. 104 (1951). 24 pp. This bulletin summarizes the laws and the procedures of the Sanitary Water Board in enforcing them. Water handling to avoid or to reduce contact with sulfuritic materials is suggested as the only satisfactory way to limit acid mine drainage. Regulations for water handling at several experimental strip mines are outlined. OR 51-34

MD51-5 COLLECTION AND TREATMENT OF ACID RUNOFF FROM COAL GOB-PILE-STORAGE AREAS

Gross, C. D. (1) and Lee, C. (2) [(1) Ill. Sanit. Water Bd. (2) Peabody Coal Co.], Eng. Ext. Ser. No. 76, Purdue Univ., Proc. 6th Ind. Waste Conf., Feb. 21-23, 1951. pp 10-21. The cause of fish kills in the South Fork of the Sangamon River in the late 1940's was found to be runoff from the coal refuse piles of a mine and a coal processing plant. Part 1 describes how this cause was established. Part 2 describes the method by which drainage to the stream was impounded and discharged at a controlled rate in proportion to stream flow. At a 50 to 1 ratio of stream water to acid waste water the pH of the mixture remained at 6 or above. OR 51-36

MD51-6 CHEMICAL CHARACTER OF SURFACE WATERS OF OHIO 1946-1950

Lamar, W. L. and Schroeder, M. E., Ohio Dept. Natural Resour., Div. Water, Bull. 23 (1951). 100 pp. The chemical characteristics which were examined are described briefly and descriptions of the river basins included in the survey are given. The results of a cooperative testing program with the U.S. geological survey are tabulated. OR 51-24

MD51-7 SPECIAL REPORT ON A STUDY OF THE ROLE OF AUTOTROPHIC BACTERIA IN THE FORMATION OF MINE ACID (July 1949 - July 1951)

Leathen, W. W. and Braley, S. A., Mellon Inst. Special Rept. to Pa. Dept. Health, Ind. Fellowship No. 326B, 1951. 211 pp. Studies to clarify the roles of iron and sulfur oxidizing bacteria are reported. OR 51-21

MD51-8 OHIO RIVER VALLEY WATER SANITATION COMMISSION - THIRD ANNUAL REPORT

Cincinnati, Ohio, 1951. 36 pp. An outline of program activities includes details

MD51-8 (continued)

of technical studies, river investigations and educational campaign. Status reports, by states, on municipal sewage treatment installations are given. OR 51-14

MD51-9 INVESTIGATIONS ON COAL MINE DRAINAGE - ANNUAL REPORT, JULY 1950 - JULY 1951

Temple, K. L., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, July 1951. 8 pp. The study of the bacterium which is responsible for the oxidation of ferrous iron in acid mine waters has been completed and the organism has been given the name Thiobacillus ferrooxidans. Data from a study of three cores extending 130 to 140 inches above the top of the Sewickley and Pittsburgh seams show a wide variability in the percent sulfur of the various strata above the coal in a single core sample. This is consistent with the observation that the formation of acid is a local phenomenon and that composition of the roof strata is the variable that determines the differences between seams and mines. (Adapted from summary) OR 51-26

MD51-10 THE AUTOTROPHIC OXIDATION OF IRON BY A NEW BACTERIUM: THIOBACILLUS FERROOXIDANS

Temple, K. L. and Colmer, A. R., J. Bacteriol. 62 (5), 605-611 (1951). An iron-oxidizing bacterium from acid mine water has been shown to live autotrophically upon inorganic media containing ferrous iron under conditions such that atmospheric oxidation is excluded. The bacterium which also grows autotrophically on thiosulfate, has been assigned to the genus Thiobacillus and the specific name Thiobacillus ferrooxidans n. sp. is suggested. (From authors' Summary) OR 51-30

MD51-11 THE FORMATION OF ACID MINE DRAINAGE

Temple, K. L. and Colmer, A. R., Trans. AIME 190, 1090-1092 (1951). The role of microorganisms in the formation of acid mine water is discussed. OR 51-15

MD51-12 THE FORMATION OF ACID MINE DRAINAGE

Temple, K. L. and Colmer, A. R. (W. Va. Univ.), Eng. Ext. Ser. No. 76, Purdue Univ., Proc. 6th Ind. Waste Conf., Feb. 21-23, 1951. pp 285-291. This paper is a review of the biological aspects of acid mine water in relation to ferrous ion oxidation and sulfur oxidation. OR 51-37

MD51-13 INVESTIGATIONS ON COAL MINE DRAINAGE - SEMI-ANNUAL REPORT, JULY 1950 - DECEMBER 1950

Temple, K. L. and Colmer, A. R., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Feb. 1951. 11 pp. The importance of Thiobacillus thiooxidans in the formation of acid is further investigated. The formation of acid in exposed roof shales is further supported and its significance explored. OR 51-25

1952

MD52-1 SURFACE-WATER SEEPAGE INTO ANTHRACITE MINES IN THE LACKAWANNA BASIN NORTHERN FIELD, ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H., Eaton, W. L., and Whaite, R. H., U.S. Bur. Mines, Bull. 518 (1952). 37 pp.+ This engineering study of 52 streams in the area (not including the Lackawanna River) identifies the estimated volume, source of seepage, and probable receiving underground pools, drainage tunnel, and pumping plants; and compares the total estimated seepage to each pumping plant with the volume of water pumped by each plant during 1948. (From Introduction) OR 52-2

MD52-2 EXPERIMENTAL STRIP MINES SHOW NO STREAM POLLUTION

Braley, S. A., Mining Congr. J., Reprinted from Sept. 1952. 2 pp. The basic rules to be followed to prevent stream pollution from surface mines are: (1) keep water out as much as possible by drainage ditches located to isolate the area being worked; (2) segregate sulfur-bearing shale; (3) cover sulfur-bearing material with compacted top cover. The problems vary from one operation to another and any legislation should be flexible enough to permit most effective use of the techniques available. OR 52-3

MD52-3 MINE ACID CONTROL

Braley, S. A., Mellon Inst., Spec. Summary Rept., to Pa. Dept. Health, Ind. Fellowship No. 326B-6, 1952. 22 pp. The results of flow and acid concentration studies conducted over a three to four year period are summarized. It had been generally believed that the amount of H_2SO_4 delivered by a given mine was a constant per unit time, but these data demonstrated that the weight of acid was constant for a unit volume of water outflow. Procedures for reducing flow from a mine are discussed. Resulting decrease in acidity at both underground and surface mines is noted. OR 52-39

MD52-4 MINE WATER TREATMENT

Braley, S. A., Proc. First Ohio Water Clinic, Ohio State Univ. Studies, Eng. Ser. Bull. 147, 114-118 (1952). The amount of acid mine water discharged into our streams can only be controlled by obtaining sufficient on-the-spot data upon which to base regulations and then applying these regulations to each individual mine according to the existing conditions. (From author's conclusions) OR 52-21

MD52-5 CONTROL OF ACID DRAINAGE FROM COAL MINES

Pa. Sanit. Water Bd., 1952. 28 pp. This booklet discusses means for reducing the pollution of streams by coal mine drainage by controlling the contact of water with sulfur bearing compounds and by neutralization of standing pools. Applications to surface mines, underground mines, and mine waste minerals are discussed. OR 52-1

MD52-6 THE RECREATIONAL USE OF WATER IN OHIO

Dambach, C. A., Proc. First Ohio Water Clinic, Ohio State Univ. Studies, Eng. Ser. Bull. 147, 27-33, 1952. There is a lack of water available for recreational use in Ohio. Pollution of streams such as Raccoon Creek further limits water-related recreation. OR 52-16

MD52-7 VIABILITY OF _ESCHERICHIA COLI_ IN ACID MINE WATERS

Joseph, J. M. and Shay, D. E., Am. J. Pub. Health _42_, 795-800 (1952). _E. coli_ and a few other microorganisms can tolerate acid conditions in small numbers. Self-purification studies in situ showed that purification is not complete. OR 52-7

MD52-8 MICROBIOLOGICAL STUDIES OF BITUMINOUS COAL MINE DRAINAGE

Leathen, W. W., Mellon Inst., Spec. Summary Rept., to Pa. Dept. Health, Ind. Fellowship No. 326B-6, 1952. 54 pp.+ The report covers a five-year study of the role of bacteria in bituminous coal mine drainage. Unclassified iron oxidizing bacteria and sulfur oxidizing bacteria identified as _Thiobacillus thiooxidans_ were found in all mine drainages studied. Sulfate reducing bacteria, some algae, and protozoa were also occasionally present. _T. thiooxidans_ did not enhance acid formation from sulfur ball or museum grade pyrite but did slightly enhance acid formation from marcasite. The iron oxidizing bacteria caused a several-fold increase in acidity formed from sulfur ball and from marcasite but did not affect pyrite. The iron oxidizing bacteria were also assumed to increase the rate of ferrous iron oxidation in mine water. (Adapted from author's conclusions) OR 52-37

MD52-9 HISTORY AND PROGRESS MADE IN MINE SEALING TO REDUCE THE FLOW OF ACID MINE WATER INTO THE STREAMS OF THIS COMMONWEALTH

Maize, R., Presented, Coal Mining Inst., Pittsburgh, Pa., Dec. 1952. 23 pp. In addition to presenting a history and discussion of the mine sealing program in Pennsylvania, this paper contains twelve illustrations of methods of sealing mines. OR 52-31

MD52-10 A PROPOSED SEALED CIRCULAR COAL-REFUSE PILE

Nelson, W. L. and Hall, E. P., Mechanization 16 (12), 85-89 (1952). Well compacted and sealed piles may cost much less than control of fires and assessments for damages from unsealed piles. A detailed description of a proposed sealed circular coal-refuse pile is given together with cost calculations for the sealing operation on piles of different diameters. OR 52-29

MD52-11 OHIO RIVER VALLEY WATER SANITATION COMMISSION - FOURTH ANNUAL REPORT

Cincinnati, Ohio, 1952. 24 pp. This is an accounting of activities and projects of the Commission. OR 52-12

MD52-12 METHODS OF REDUCING WATER POLLUTION BY THE COAL MINING INDUSTRY

Spokes, E. M., Proc. Ky. Mining Inst., 1951/1952. pp 107-111. As a first step in controlling water pollution, a careful appraisal of the individual source of pollution is necessary. No economical solution for the acid mine water problem has yet been found; however, methods of removal of suspended solids from preparation plant waste water have been shown to be practical. The University of Kentucky is prepared to cooperate with coal companies in research on these problems. OR 52-30

MD52-13 INVESTIGATIONS ON COAL MINE DRAINAGE - INTERIM REPORT NO. 19

Temple, K. L., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, Nov. 1952. 13 pp. The role of ferric sulfate in acid production was studied. Ferric sulfate solutions with four different sulfuritic materials showed no increase of acid with two types of sulfur ball and with a Freeport composite, but showed a delayed and marked increase in acid production from a third sulfur ball material. In other experiments on the effect of bacteria on acid production from sulfur ball, Thiobacillus thiooxidans increased acidity 30-50 percent while Thiobacillus ferrooxidans increased acidity approximately 100 percent. OR 52-40

MD52-14 INVESTIGATIONS ON COAL MINE DRAINAGE - SEMI-ANNUAL REPORT, JULY 1951 TO JANUARY 1952

Temple, K. L., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, March 1952. 8 pp.+ The study of roof strata in an acid forming area and the effect of the bacterial population on the rate of acid formation are reported. An acid producing surface mine is also described. Experiments on particle size of pyrites and sulfur in relation to acid formation are investigated. OR 52-36

MD52-15 INVESTIGATIONS ON COAL MINE DRAINAGE - SEMI-ANNUAL REPORT, JANUARY 1952 TO JULY 1952

Temple, K. L., W. Va. Univ., Eng. Expt. Sta., Ind. Res. Fellowship No. 11, July 1952. 34 pp. Three aspects of acid formation under investigation are: the effect of ferric sulfate on formation from sulfuritic material, the effect of iron- and sulfur-oxidizing bacteria, and the geologic evaluation of an acid producing area. A bibliography of material pertinent to the study of acid mine drainage is included. OR 52-27

1953

MD53-1 MINE PUMPING PLANTS - ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H., Hower, C. S., Kennedy, D. O., and Lesser, W. H., U.S. Bur. Mines, Bull. 531 (1953). 151 pp. Data on the volume and quality of the mine water pumped in the anthracite region during the period 1944-1951 is tabulated. Information is also included on kinds of pumps used and their performance. OR 53-2

MD53-2 SURFACE-WATER SEEPAGE INTO ANTHRACITE MINES IN THE WESTERN MIDDLE FIELD ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H. and Link, H. B., U.S. Bur. Mines, Bull. 532 (1953). 26 pp. This report summarizes the engineering study, conducted in 1952, in which 47 streams in the area were examined. Information was collected on drainage area, length of stream bed within coal measures, length of previous stream bed, length of existent improvements, and estimated volume of seepage. Total estimated seepages to pumping plants are compared with volumes of water pumped to the surface during 1948. Most of the water infiltrating the mines was found to be general surface seepage. OR 53-3

MD53-3 SURFACE-WATER SEEPAGE INTO ANTHRACITE MINES IN THE WYOMING BASIN NORTHERN FIELD-ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H. and Whaite, R. H., U.S. Bur. Mines, Bull. 534 (1953). 30 pp. This report summarizes the engineering study, conducted in 1950 and 1952, in which 59 streams were investigated. Information was collected on drainage area; length of stream bed within coal measures; length of previous stream bed; length of existent improvements; and estimated volume of seepage. Total estimated seepages to pumping plants are compared with volumes of water pumped to the surface during 1948. Approximately 30 percent of the water pumped annually from mines in this area is from surface seepage. Twenty-one percent is from seepage through previous stream beds. Forty-nine percent is from seepage through the bed of the Susquehanna River.
OR 53-4

MD53-4 COMMON FALLACIES ABOUT ACID MINE WATER

Beal, G. D. (Mellon Inst.), Issued by Pa. Sanit. Water Bd., Jan. 1953. 12 pp. The paper discusses the origin of acid mine water and gives the answers to some 15 common fallacies about acid mine water. While all mining operations should be laid out in such a manner as to avoid the collection of acid water in the mine, there should be maintained a continuous water survey in the mine. Because ground water is normally alkaline where it enters a mine, it is often possible to conduct that water to the acid producing area and then pump the neutralized water out of the mine. OR 53-8

MD53-5 STREAM POLLUTION BY COAL MINE WASTES

Hebley, H. F., Trans. AIME 196, 404-412 (1953). This paper contains a general description of the nation's water resources. It touches upon the phenomenal growth in the demand for water supply and emphasizes the problems facing the coal industry both with regard to acid mine water drainage discharged from active and abandoned mines and the suspended solids discharged to the stream system from wet coal preparation plants. Discussions of acid mine drainage investigations of Braley and others and the bacteriological approach as presented by Temple and Colmer and others are included. Problems in abating pollution from acid mine drainage and from coal washing water are related to the tremendous increase in water use.
OR 53-9

MD53-6 WASTE DISPOSAL PROBLEMS IN THE COAL MINING INDUSTRY

Hodge, W. W. (Mellon Inst.), in "Industrial Wastes, Their Disposal and Treatment," W. Rudolfs, Ed., New York: Reinhold, 1953. pp 312-449. The disposal of acid

MD53-6 (continued)

runoff from gob piles and acid mine drainage from anthracite, bituminous, and surface mines is reviewed as one of the problems of waste disposal in the coal mining industry. Also considered are theories on formation of acid mine drainage, sulfur containing material, bacteria in acid mine drainage, and effects of mine drainage. Methods of reducing pollution from acid mine waters are described and evaluated. OR 53-33

MD53-7 HOW TO AVOID STREAM POLLUTION FROM ACID MINE DRAINAGE

Coal Age 58 (2), 96-101 (1953). This is a review of "Control of Acid Drainage from Coal Mines," published by the Pennsylvania Sanitary Water Board in 1952. OR 53-35

MD53-8 MICROBIOLOGICAL STUDY OF ACID MINE WATERS - PRELIMINARY REPORT

Joseph, J. M., Ohio J. Sci. 53 (2), 123-127 (1953). This is a preliminary study to isolate, cultivate, observe, and attempt identification of the various kinds of organisms capable of tolerating conditions existing in acid waters and to observe the direct or indirect effects of acid waters upon the existing microorganisms. Bacteria, fungi, and diatoms may exist in acid waters. Some of the bacteria, fungi, and diatoms found are listed, however there is a great reduction of microfauna in acid waters. OR 53-6

MD53-9 BACTERIOLOGIC ASPECTS OF BITUMINOUS COAL MINE EFFLUENTS

Leathen, W. A., Proc. Pa. Acad. Sci. 27, 37-44 (1953). The results of studies on acid mine water at Mellon Institute are summarized. Sulfur oxidizing bacteria did not increase the formation of acid, but iron oxidizing bacteria increased the total acidity of mine waters substantially. Since methods of controlling bacterial activity inside or outside the mine appear impractical, rapid removal of water from the mine was recommended. OR 53-1

MD53-10 THE ROLE OF BACTERIA IN THE FORMATION OF ACID FROM CERTAIN SULFURITIC CONSTITUENTS ASSOCIATED WITH BITUMINOUS COAL. I. THIOBACILLUS THIOOXIDANS; II. FERROUS IRON OXIDIZING BACTERIA

Leathen, W. W., Braley, S. A., Sr., and McIntyre, L. D. (Mellon Inst.), Appl. Microbiol. 1 (2) (1953). I., pp 61-64; II., pp 65-68. Thiobacillus thiooxidans was found to produce acid from museum grade marcasite but not from sulfur ball material nor from museum grade pyrite. The unclassified iron oxidizing bacteria produced acid and sulfate from sulfur ball material and from museum grade marcasite but not from pyrite. OR 53-16

MD53-11 MINE DRAINAGE

McGee, E. I., Mining Congr. J. 39 (8), 42-45 (1953). Selection of proper pumps and piping for draining mines and maintenance problems encountered are discussed. Water which is often acid and carries abrasive material can be destructive unless care has been taken to use materials which are not readily attacked. OR 53-18

MD53-12 ACID MINE DRAINAGE CONTROL IN PENNSYLVANIA

Morgan, L. S., Proc. Second Ann. Ohio Water Clinic, Ohio State Univ. Studies, Eng. Ser. 22 (4), 85-93 (1953). The source of acid, its effect on stream composition, and possible methods of abatement are discussed. OR 53-17

MD53-13 OHIO RIVER VALLEY WATER SANITATION COMMISSION - FIFTH ANNUAL REPORT

Cincinnati, Ohio, 1953. 28 pp. Reports of the various industry advisory committees are included as part of this discussion of the accomplishments of the Commission. OR 53-14

1954

MD54-1 THE MINING AND CLEANING OF COAL AT THE DOUGLAS COLLIERY

Anderson, W., S. African Ind. Chemist 8 (9), 201-206 (1954). The mining and preparation processes at Douglas Colliery in South Africa are described. The mine water has an average pH value of 8.0 and a high soda content has been found. Fine coal suspended in the washery water is removed by draining the effluent through a waste dump and into a small dam. It is reused in coal cleaning. OR 54-23

MD54-2 SURFACE-WATER SEEPAGE INTO ANTHRACITE MINES IN THE SOUTHERN FIELD--ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H., Link, H. B., and Romischer, W. M., U.S. Bur. Mines, Bull. 539 (1954). 52 pp.+ This report summarizes the engineering study conducted during 1953. The data show the volume and type of seepage in the drainage area and point to the value of repairing stream beds and surface areas overlying the coal measures as part of the solution of the mine-water problem affecting the mines in this field. OR 54-4

MD54-3 ACID MINE DRAINAGE. I. THE PROBLEM

Braley, S. A., Mechanization 18 (1), 87-89 (1954). The natural production of acid drainage from coal associated materials is outlined. Some early observations of mine drainage are noted. OR 54-5

MD54-4 ACID MINE DRAINAGE. II. SOURCES

Braley, S. A., Mechanization 18 (2), 113-115 (1954). The natural chemical oxidation of FeS_2 is the principal source of coal mine acid. Thiobacillus thiooxidans and iron-oxidizing organisms are always present, because they grow and thrive in the acid environment but they have little effect on the total acid production. The mechanism of oxidation is discussed. OR 54-6

MD54-5 ACID MINE DRAINAGE. III. SAMPLING AND ANALYSIS

Braley, S. A., Mechanization 18 (3), 96-98 (1954). The article describes the method of taking a proper representative sample of mine or stream water and how to handle it prior to analysis. Also described are laboratory methods of determining the acidity and pH of the sample. Relationship between actual acidity and pH of the stream samples is discussed. OR 54-7

MD54-6 ACID MINE DRAINAGE. IV. COMPOSITION AND FLOW

Braley, S. A., Mechanization 18 (4), 137-138 (1954). The article lists data obtained from the sampling of streams into which acid mine-water is discharged. The author demonstrates how such data must be interpreted and concludes that each mine must be studied separately to determine its effect on stream pollution. No overall rule can be established that will cover all cases of mine-water discharge. OR 54-8

MD54-7 ACID MINE DRAINAGE. V. CONTROL OF MINE ACID

Braley, S. A., Mechanization 18 (5), 97-98 (1954). No economically feasible method for control of acid in mine drainage is presently known. The best avenue of control is to plan the drainage course so that water does not accumulate in pools in the mine but is removed as rapidly as possible. OR 54-9

MD54-8 ACID MINE DRAINAGE. VI. CONTROL OF OXIDATION

Braley, S. A., Mechanization 18 (6), 105-107 (1954). The conventional procedure of "mine sealing" is ineffective in control of oxidation unless the coal seam is deep enough that the mine can be completely flooded by natural inflow of water and thus

MD54-8 (continued)

seal itself against air contact with sulfuritic material. OR 54-10

MD54-9 ACID MINE DRAINAGE. VII. STRIP MINING

Braley, S. A., Mechanization 18 (8), 101-103 (1954). Proper drainage, separation of sulfuritic material, and proper backfilling will eliminate or greatly reduce the formation of acid water in open-pit mines without major additional cost. OR 54-11

MD54-10 SUMMARY REPORT OF COMMONWEALTH OF PENNSYLVANIA (DEPARTMENT OF HEALTH) INDUSTRIAL FELLOWSHIP NOS. 1 TO 7 INCL.

Braley, S. A., Mellon Inst. Fellowship No. 326B (1954). 279 pp. Investigations were carried out on the nature and composition of mine discharge; the source and reaction by which it is formed, including the role of bacteria; the methods by which the acid is carried through and from the mines; the relationship between concentration on volume of flow on a seasonal basis, the seasonal effect on streams; and the effect of self-purification on streams. No satisfactory or economical method for prevention of acid formation in underground mines has been found; however, a fund of information which provides better understanding of the mine acid problem is presented. OR 54-28

MD54-11 STUDIES OF ACID MINE WATERS WITH PARTICULAR REFERENCE TO THE RACCOON CREEK WATERSHED

Clifford, J. E. and Snavely, C. A., Battelle Memorial Inst., Rept. to Ohio Dept. Natural Resour., Div. Wildlife, 1954. 134 pp.+ This comprehensive examination of the acid mine water problem in the Raccoon Creek, Ohio, watershed covers in detail the sources of acid (strip, drift, slope, shaft mines, gob piles), neutralization, abatement through mine sealing, reservoir, and drainage control, cost analysis of various approaches, and presence of other minerals and their overall influence on the problem. Appendix B is "A Correlated Abstract, Review and Bibliography of the Published Literature Relating to Acid Mine Drainage." OR 54-1

MD54-12 A PRELIMINARY REPORT ON A PROCESS FOR PREVENTION OF ACID MINE WATERS

Cotton, E. R., Interstate Comm. Potomac River Basin, 1954. Unpublished. The behavior of pyrite and marcasite in the laboratory is compared with that in the mines and the differences in reactions are analyzed. Decomposition is much more rapid in the mines probably due to the presence of hydrogen sulfide, which breaks down into elemental sulfur, hydrogen, and free electrons. Hydrogen then combines with water and oxygen to form hydrogen peroxide which combines with sulfur or pyrites to form iron salts or sulfuric acid. Interrupting this series of reactions by the presence of a metal which has a higher electrical potential than that of sulfur or iron would theoretically prevent acid drainage formation. Field tests seem to confirm the theory but are incomplete. OR 54-30

MD54-13 STREAM POLLUTION FROM COAL MINES

Hebley, H. F., Proc. Third Ann. Ohio Water Clinic, Ohio State Univ. Eng. Conf. Ser., 1954. pp 41-44. Both suspended solids from coal cleaning plants and acid water draining from mines are pollution problems. Recent research on mine drainage and its applications, and methods for removing suspended solids are discussed. OR 54-20

MD54-14 FUNDAMENTAL RESEARCH IN WATER POLLUTION ABATEMENT AT MELLON INSTITUTE

Hoak, R. D., Presented, Pittsburgh Regional Tech. Meet. Am. Iron Steel Inst., 1954. 17 pp. The activities of the Fellowship in the field of water pollution abatement are discussed. They include a study of iron oxidation in a stream from an abandoned coal mine. OR 54-3

MD54-15 A NEW IRON-OXIDIZING BACTERIUM: FERROBACILLUS FERROOXIDANS

Leathen, W. W. and Braley, S. A., Reprinted from Bacteriol. Proc., May 1954. 1 pp. A physiologic study of ferrous iron oxidizing bacteria isolated from bituminous coal mine effluents warrants the establishment of a new genus: Ferrobacillus. The specific designation Ferrobacillus ferrooxidans is proposed for the bacterium. OR 54-19

MD54-16 PHYSICO-CHEMICAL CHARACTERISTICS OF PONDS IN THE PYATT, DESOTO, AND ELKVILLE STRIP MINED AREAS OF SOUTHERN ILLINOIS

Lewis, W. M. and Peters, C. (Southern Ill. Univ., Carbondale), Trans. Am. Fisheries Soc. 84, 117-124 (1954). The ponds were studied both in winter and in summer. Among the findings were that there was high concentration of dissolved oxygen in the thermocline, pH values ranged from 3 to 8, and specific conductance was high. Not all ponds supported fish. In the ponds where fish lived, green sunfish, bluegill, and largemouth bass were the most common species. OR 54-37

MD54-17 THE WEATHERING OF PYRITE

Mapstone, G. E., Chem. and Ind., 577-578 (1954). A probable scheme for the course of weathering of pyrite is based on experimental observation of the heterogeneous reaction. The series of reactions outlined can explain all the products reported from weathering of pyrite: ferrous sulfide, free sulfur, sulfur dioxide, and ferrous sulfate. OR 54-13

MD54-18 A PRELIMINARY SURVEY OF FOOD HABITS OF THE FISH AND PHYSICO-CHEMICAL CONDITIONS OF THE WATER OF THREE STRIP-MINE LAKES

Maupin, J. K., Wells, J. R., and Leist, C. (Kans. State Teachers College, Pittsburg), Trans. Kans. Acad. Sci. 57 (2), 164-171 (1954). This project, conducted for the purpose of improving fish production in surface-mine areas of southeastern Kansas, was a study of three surface-mine lakes in Crawford County. Physico-chemical data included temperature, hydrogen ion concentrations, oxygen, carbon dioxide, and carbonate concentration. Biological data included qualitative and quantitative study of benthic organisms and the occurrence of such organisms in the stomachs of captured fish. Benthic organisms were not found to be the primary source of food for fish. Although one lake was more than twice as old as the other two and was also much more shallow, physico-chemical characteristics of the three lakes were similar. OR 54-36

MD54-19 OHIO RIVER VALLEY WATER SANITATION COMMISSION - SIXTH ANNUAL REPORT

Cincinnati, Ohio, 1954. 24 pp. The activities of the Commission together with lists of people working on the various committees are presented. A discussion of sewage treatment standards forms an important part of the report. OR 54-16

MD54-20 DRAINAGE FROM BITUMINOUS COAL MINES

Temple, K. L. and Koehler, W. A., W. Va. Univ., Eng. Expt. Sta., Res. Bull. 25 (1954). 35 pp. This investigation was sponsored by Bituminous Coal Research, Inc. A detailed discussion of the source, composition, and properties of acid mine water is presented. The role of iron and/or sulfur-oxidizing bacteria is discussed. Possible courses of research on the prevention of acid formation are set forth, with the conclusion that no practical approach has yet been discovered. OR 54-2

1955

MD55-1 ACID DRAINAGE

Business Week, No. 1364, 123 (Oct. 22, 1955). The theory of Patrick and McCollum of Johns Hopkins of the polar nature of the pyrite reaction led to laboratory tests

MD55-1 (continued)

that indicate that solutions of phosphate or chromate sprayed on the pyrite would halt the formation of H_2SO_4. OR 55-9

MD55-2 CORROSIVE AND EROSIVE EFFECTS OF ACID MINE WATERS ON METALS AND ALLOYS FOR MINE PUMPING EQUIPMENT AND DRAINAGE FACILITIES, ANTHRACITE REGION OF PENNSYLVANIA

Ash, S. H., Dierks, H. A., Felegy, E. W., Huston, K. M., Kennedy, D. O., Miller, P. S., and Rosella, J. J., U.S. Bur. Mines, Bull. 555 (1955). 46 pp. This report presents data on the corrosive and erosive effects of acid mine water as well as data on the volume and quality of water pumped from underground workings. Twenty-five different metals and alloys were studied. Corrosion tests utilized the two methods (weight loss and microscopic examination) most likely to yield valid data on the behavior of metals and alloys in the environment in which pumping equipment constructed from these materials will operate. OR 55-1

MD55-3 FLOOD PREVENTION IN ANTHRACITE MINES, WESTERN MIDDLE AND SOUTHERN FIELDS, PROJECT NO. 2

Ash, S. H., Dierks, H. A., Kynor, H. D., Lesser, W. H., Miller, P.S., and Romischer, W. M., U.S. Bur. Mines, Bull. 546 (1955). 37 pp.+ This report covers the second in a series of five projects into which the Conowingo tunnel system has been divided for geographical and practical reasons. Project No. 2 covers the Western Middle and Southern fields and deals with the following items: (a) economic development, (b) geology and hydrology, (c) statement of basic problem, (d) plan and cost of work contemplated, (e) economic analysis and justification of project, and (f) recommendations and conclusions. This report describes the second section of the proposed Conowingo tunnel drainage system. Information is included on the geology and hydrology of the area and on the plan and costs of the work to be done. OR 55-10

MD55-4 FLOOD PREVENTION IN ANTHRACITE MINES, NORTHERN FIELD, PROJECT NO. 3 (WYOMING)

Ash, S. H., Dierks, H. A., Kynor, H. D., Lesser, W. H., Miller, P. S., and Romischer, W. M., U.S. Bur. Mines, Bull. 547 (1955). 35 pp.+ This third section of the Conowingo tunnel system is a self-contained drainage unit that will permit unwatering inundated mines and safeguarding active mines in the Wyoming Basin of the northern field and also will handle the water in the Lackawanna Basin. OR 55-11

MD55-5 THE INFLUENCE OF BACTERIA IN THE FORMATION OF ACID MINE WATERS

Ashmead, D., Colliery Guardian 190, 694-698 (1955). Experiments have shown that the cause of the acid mine waters at two collieries in the Scottish Division of the National Coal Board is the oxidation of pyrites chemically and bacterially to form ferric hydroxide and sulfuric acid. Approximately four times as much sulfuric acid is produced by bacteriological means than by chemical means. OR 55-7

MD55-6 A GUIDE TO THE CLARIFICATION OF COAL WASHERY WASTE WATER

Gillenwater, L. E., W. Va. State Water Comm., 1955. 35 pp.+ Some of the methods which have been applied to washery waters to control pollution are discussed in detail. OR 55-14

MD55-7 COAL INDUSTRY REPORTS

Hebley, H. F., Proc. 1954 Pa. Clean Streams Conf., Pa. State Chamber Commerce Bull. 146, 1955. pp 20-24. The characteristics of pollution from mine drainage and from coal washery water and the problems of pollution abatement are discussed. A discussion of the report by S. A. Braley is included. OR 55-15

MD55-8 INTERPRETATION OF REACTIONS IN ACID THIOSULFATE MEDIA

Leathen, W. W. and Braley, S. A., Sr. (Mellon Inst.), J. Bacteriol. 69 (4), 481 (1955). Since acidic thiosulfate media has been shown to have a loss in reducing power and a drop then a rise in pH, indications of decomposition of thiosulfate, the advisability of using such media to characterize bacteria found in bituminous coal mine effluents has been questioned. OR 55-28

MD55-9 OHIO RIVER VALLEY WATER SANITATION COMMISSION - SEVENTH ANNUAL REPORT

Cincinnati, Ohio, 1955. 23 pp. This is a report of the work of the commission and its various committees in the seventh year of its existence. OR 55-8

MD55-10 EFFECTS OF ACID STRIP MINE POLLUTION ON THE ECOLOGY OF A CENTRAL MISSOURI STREAM

Parsons, J. D., Ph.D. Thesis, Univ. Mo. (1955). 185 pp. Univ. Microfilms, Ann Arbor, Mich. The sources of acid pollution of Cedar Creek are surface-mined areas, including surface-mine lakes, which are close to the headwaters of the creek. From June 1952 through August 1954, water samples were taken at 12 stations. Values for oxygen, alkalinity, acidity, sulfate, ferric and ferrous iron, copper, zinc, calcium, magnesium, aluminum, lead, phosphorus, and bicarbonate, as well as temperature are reported. Biological evaluation of the creek included a determination of the type and extent of plankton, benthos, and fish population. Four excessive acid flows into the creek during the study period were investigated, and their relationship to rainfall observed. Three of the surface-mined lakes studied were red lakes, colored by suspended iron oxides and three were blue lakes, colored by reflection and with no turbidity. Water samples from the lakes were analyzed for the same components as samples taken in the creek, and were collected at the surface, at each 5 foot interval, and at the bottom. Red lakes were found to be thermally stratified during spring and summer months while blue lakes were homothermous. OR 55-29

1956

MD56-1 FLOOD PREVENTION IN ANTHRACITE MINES, ANTHRACITE REGION OF PENNSYLVANIA PROJECTS NOS. 4 AND 5

Ash, S. H., Dierks, H. A., Kennedy, D. O., and Miller, P. S., U.S. Bur. Mines, Bull. 560 (1956). 23 pp.+ These projects are concerned with the construction of gravity-flow tunnels connecting with three other projects. The complete system would be known as the Conowingo tunnel system. OR 56-8

MD56-2 THE INFLUENCE OF BACTERIA IN THE FORMATION OF ACID MINE WATERS. PART 2

Ashmead, D., Colliery Guardian 192, 483-487 (1956). In laboratory studies, oxidation of iron disulfide was prevented or decreased in the presence of quaternary ammonium compounds, in the absence of oxygen, and at pH greater than 4. OR 56-12

MD56-3 AQUATIC AND MARGINAL VEGETATION OF STRIP MINE WATERS IN SOUTHERN ILLINOIS

Bell, R., Ill. Acad. Sci. Trans. 48, 85-91 (1956). Fifty-two of the numerous surface mine ponds in the area were included in this study. Plant distribution was correlated with physico-chemical characteristics. Species listed were categorized as submerged, floating, emergent, moist soil, and recession zone vegetation. OR 56-29

MD56-4 TRUTH AND FALLACY ABOUT A SERIOUS PROBLEM: ACID COAL MINE DRAINAGE

Braley, S. A., Trans. AIME 205, 314-318 (1956). Both field and laboratory experiments are discussed. The conclusions based on these experiments are: application of gaseous NH_3 to an interior surface was ineffective; phosphates, chromates, or

MD56-4 (continued)

NaOH have little effect upon the rate of oxidation of pyrite or pyritic material; reaction rate of pyritic material from a coal measure is greater than the reaction rate of yellow pyrite; the reaction rate of sulfuritic waste is greatly increased by aeration either wet or dry; pH determination is a poor criterion of reaction rate in buffered solutions; there is no known inhibitor capable of deterring or stopping the reaction between the sulfuritic material associated with the coal measures and the oxygen in the air. OR 56-7

MD56-5 CONTROL OF SLUDGE VOLUMES FOLLOWING LIME NEUTRALIZATION OF ACID WASTES

Faust, S. D., Orford, H. E., and Parsons, W. A., Sewage Ind. Wastes 28 (7), 872-881 (1956). The objective of this study was to systematically investigate crystal seedings as a means of concentrating sludges formed from lime neutralization of sulfuric acid wastes. The three processes presented are the addition of native gypsum powder, the return of a sludge initially seeded with gypsum, and the return of unseeded sludge. OR 56-6

MD56-6 FROM FOOL'S GOLD TO STREAM POLLUTION

Clean Waters for Ohio (Ohio Water Pollut. Contr. Bd.) 5 (1), 2-7 (1956). This general description of the mine drainage problem includes the report of a field trip to consider steps to be taken to improve the streams in the Raccoon Creek area. OR 56-10

MD56-7 AEDES SOLLICITANS IN ILLINOIS

Horsfall, W. R., J. Econ. Entomol. 49 (3), 416 (1956). *Aedes sollicitans*, the saltmarsh mosquito, is limited in Illinois to areas where solutes in wastes particularly from coal mines collect in soil subject to transient flooding. At almost all oviposition sites there is a sulphurous odor to the soil. OR 56-19

MD56-8 FERROBACILLUS FERROOXIDANS: A CHEMOSYNTHETIC AUTOTROPHIC BACTERIUM

Leathen, W. W., Kinsel, N. A., and Braley, S. A., Sr., J. Bacteriol. 72, 700-704 (1956). The chemosynthetic autotroph, *Ferrobacillus ferrooxidans*, oxidizes ferrous to ferric ions. It is distinguished from the genus *Thiobacillus* since it oxidizes neither sulfur nor thiosulfate under favorable environmental conditions. OR 56-18

MD56-9 COAL MINE SLAG DRAINAGE: TOXICITY TO REPRESENTATIVE FISHES

Lewis, W. M. and Peters, C. (Southern Ill. Univ., Coop. Fisheries Res. Lab.), Ind. Wastes 1 (14), 145-147 (1956). Acid drainage of known composition from slag heaps at the Delta Mine near Crab Orchard, Ill. was added to fish tanks containing river water. Green sunfish, largemouth bass, and carp were used in the trials. A concentration of 1 to 50 was found to be the lethal addition of drainage to river water. It was also determined that the death of the fish was caused by the free acidity of the mixture and not by the iron flocculent which was also present in great quantities in tanks where the fish survived. OR 56-31

MD56-10 OHIO RIVER VALLEY WATER SANITATION COMMISSION - EIGHTH ANNUAL REPORT

Cincinnati, Ohio, 1956. 28 pp. In this report the Commission outlines eight years of accomplishment by eight states in a regional crusade for clean streams. OR 56-9

MD56-11 FACTORS INFLUENCING EXCESSIVE FLOWS OF COAL STRIP-MINE EFFLUENTS

Parsons, J. D. (Mo. Coop. Wildlife Res. Unit), Ill. Acad. Sci. Trans. 49, 25-33 (1956). Four excessive acid flows occurring during a study of Cedar Creek, Missouri are described in detail. Since the amount and intensity of acid flow is greatest when fed by runoff from spoil piles as well as by overflow from the acid

MD56-11 (continued)

lakes, control of drainage from the lake is recommended as the most feasible pollution control. OR 56-30

MD56-12 WASHERY WATER CLARIFICATION

Mining Congr. J. 42 (12), 67-69 (1956). The results of a survey, conducted by the Committee on Coal Preparation of the American Mining Congress, on the activities of various coal companies in washery water clarification are presented. The closed circuit and its limitations are defined. In every case where the cleaning plant operator is complying with Pure Stream legislation sludge ponds are used, either for routine impoundment of solids or for emergencies. OR 56-15

MD56-13 IMPROVEMENTS IN AND RELATING TO THE TREATMENT OF ACID WASTE WATERS AND THE LIKE

Wedekind, C. -L. and Wedekind, C., Brit. Pat. 744,480 (Feb. 8, 1956). 3 pp. This patent claims a method of neutralizing acid waste waters in which ignited magnesite is used as the basic reagent. OR 56-11

1957

MD57-1 AMERICAN STANDARD RECOMMENDED PRACTICE FOR DRAINAGE OF COAL MINES (M6.1-1955, UDC 622.5)

U.S. Bur. Mines, Bull. 570 (1957). 18 pp. This paper provides for standardized practices in using gathering pumps, permanent pumps, and piping for pumps; and in operating pumps; storing mine water; natural drainage; and unwatering abandoned workings. A section covering mine water and its action on mine-drainage equipment and another on acid-resisting metals are of particular interest. OR 57-14

MD57-2 MINE FLOOD PREVENTION AND CONTROL: ANTHRACITE REGION OF PENNSYLVANIA: FINAL REPORT OF THE ANTHRACITE FLOOD-PREVENTION PROJECT ENGINEERS

Ash, S. H., Dierks, H. A., and Miller, P. S., U.S. Bur. Mines, Bull. 562 (1957). 100 pp. The engineering survey, summarized in this report, consisted of studies on acid mine water; the geology and hydrology of the region; proposed gravity drainage tunnel system; and corrosion and erosion resistance of materials for pumps used to handle acid mine water. OR 57-1

MD57-3 EVALUATION OF MINE DRAINAGE WATER

Braley, S. A., Trans. AIME 208, 76-78 (1957). Drainage water from coal mines is probably the most serious water pollution problem today. In the extensive literature on acid mine water there appears to be a great deal of confusion about the importance of various components and the method of analysis. It is believed that total acidity or alkalinity as determined by titration in hot solution to a phenolphthalein end point is the most valuable factor in determining quality of mine water. The author believes that use of a common method of evaluating the quality of mine water discharge will eliminate much misunderstanding concerning the effect and control of mine acid. pH and various analytical methods used in characterizing mine drainage are discussed. The author concludes that the most definitive value is the determination of acidity or alkalinity by titrating in hot solution to phenolthalein end point. OR 57-4

MD57-4 MINE ACID CONTROL: A NEW APPROACH

Braley, S. A., Coal Age 62 (3), 68-69 (1957). A new mine of the Christopher Coal Co. will permit frequent water discharge to evaluate whether reduced exposure of water to acid-forming material will lead to acid mine drainage abatement. OR 57-3

MD57-5 MINE WATER PROBLEMS OF PENNSYLVANIA ANTHRACITE REGION

Dierks, H. A., Trans. AIME 208, 1140-1144 (1957). Geologic structures, character of mine water, history of engineering study, legislative action, and flood control program in action are the subjects discussed in this paper. OR 57-2

MD57-6 STREAM CLARIFICATION PROGRESS IN WEST VIRGINIA

Gillenwater, L. E., Mechanization 21 (3), 95,97 (1957). West Virginia's program of stream clarification in cooperation with the state's coal industry has shown reasonable progress. While some of the systems being installed are not of sufficient permanence to give lasting control, they represent a beginning which can be built on. OR 57-29

MD57-7 PREVENTING STREAM POLLUTION

Hebley, H. F., Mining Congr. J. 43 (8), 82-86 (1957). The two major trade wastes that are encountered in the mining and preparation of coal are acid drainage water and suspended solids. There is no system of handling acid mine water which has proven itself effective and economically feasible. A number of suggestions are made for reducing the amount of acid formed. OR 57-13

MD57-8 STREAM POLLUTION LEGISLATION OF IMPORTANCE TO THE COAL MINING INDUSTRY

Hebley, H. F. and Garvey, J. R., Unpublished, (1957). The trends in pollution controls as they affect the coal industry are discussed in some detail on a state by state basis. The legislation demonstrates a difference in approach to the problems of suspended solids in washery water discharges and the problems of acid mine water. OR 57-20

MD57-9 INVESTIGATION OF NORTH BRANCH POTOMAC RIVER: REPORT ON BENEFITS TO POLLUTION ABATEMENT FROM LOW-FLOW AUGMENTATION ON THE NORTH BRANCH POTOMAC RIVER

Rept. by U.S. Public Health Serv., Robt. A. Taft Sanit. Eng. Cent., Cincinnati, Ohio, Aug. 1957. 89 pp.+ The water quality of streams in the area has been determined as a basis for estimating quality of water impounded by dams proposed at three specific sites and also for evaluation of effects of release of these waters to streams below the proposed dam sites. Acid mine drainage is a significant cause of pollution and is considered in relation to other pollutants such as paper plant waste which, because of its alkaline character, helps neutralize the acid present in the flow above the plant. Temperature, discharge, and results of analyses for DO, BOD, and COD, suspended and dissolved solids, color, pH, alkalinity, acidity, dissolved ferric and ferrous iron, dissolved manganese, tannin, and sulfate are recorded for samples taken at 23 specified stations. Conditions existing in 1956 are compared with conditions reported in 1938 and show noticeable reduction of acid loading. OR 57-38

MD57-10 THE ACID MINE-DRAINAGE PROBLEM IN OHIO

Moulton, E. Q., Ed., Ohio State Univ., Eng. Expt. Sta., Bull. 166 (1957). 158 pp. This report presents the results of a nine month research program in acid mine-drainage including the search for information on the Federal mine sealing program. It reviews and discusses the problem, suggests future research, and presents an extensive bibliography. OR 57-10

MD57-11 THE OHIO RIVER VALLEY WATER SANITATION COMMISSION - NINTH ANNUAL REPORT

Cincinnati, Ohio, 1957. 32 pp. A brief summary of the Commission's view of acid mine drainage is given. OR 57-9

MD57-12 LITERATURE PERTAINING TO FORMATION OF ACID-MINE WASTES AND THEIR EFFECTS ON THE CHEMISTRY AND FAUNA OF STREAMS

Parsons, J. D., Ill. Acad. Sci. Trans. 50, 49-59 (1957). This literature survey covers: (1) formation of acid mine water; (2) effect of acid mine water on stream chemistry; and (3) effect of acid mine water on stream fauna. The author discusses the forms of iron sulfide and the many theories of their oxidation to acid mine water. OR 57-39

MD57-13 SCALE MODEL EXPERIMENTS FOR THE WATER TREAMENT PLANT AT THE "SCHWARZE PUMPE" WORKS

Preissler, G., Wasserwirt.-Wassertech. 7, 336-343 (1957). (Abstract 2 pp.) This abstract reference describes scale model units meeting given specifications for mixing and thereby neutralizing acidic waters with lime slurry. OR 57-36

MD57-14 ADSORPTION OF CARBON DIOXIDE BY FERROUS HYDROXIDE

Rummel, W. (Inst. fuer Wasserwirtschaft, E. Ger.), Vom Wasser 24, 110-112 (1957). (Transl. 2 pp.) Dissolved ferrous iron and free dissolved carbon dioxide are identified as the major pollutants in drainage from Lausitz lignite mines. Experiments are reported to show that in treating the mine water with lime the carbon dioxide is adsorbed on the sludge and aids in oxidizing ferrous iron. This mechanism is claimed to decrease the amount of neutralizing agent necessary. OR 57-34

MD57-15 PRODUCTION OF IRON OXIDE HYDRATE FROM MINE WATERS IN THE LAUSITZ REGION

Rummel, W. (Inst. fuer Wasserwirtschaft, E. Ger.), Wasserwirtsch.-Wassertech. 7, 344-348 (1957). (Abstract 1 pp.) This abstract reference reports that the most successful treatment of a sludge of 99.8 percent water was by vacuum filters. The amount of sludge handled was estimated at 40,000 cubic meters per day. Other drying methods and the results of using them are listed. OR 57-37

MD57-16 TREATMENT OF LIGNITE MINE WATERS HAVING A HIGH IRON AND CO_2 CONTENT

Rummel, W. (Inst. fuer Wasserwirtschaft, E. Ger.), Wasserwirt.-Wassertech. 7 (5), 183-187 (1957). (Transl. 9 pp.) The theoretical basis for a two step treatment of lignite mine drainage is given. Laboratory experiments show the effect of pH and iron content on the water content of the sludge. Generally, for the most favorable conditions for iron removal and for sludge aging (decrease of water), the pH should be kept between 6.8 and 7.4 during the first step of the treatment. Temperature, pH, ferric ion concentration, and aeration were found to affect oxidation of ferrous iron. To remove manganese, treated water is again treated with lime. The plant for initial treatment of waste water and for handling the resulting sludge is described. OR 57-35

MD57-17 WATER QUALITY AND FLOW VARIATIONS IN THE OHIO RIVER - 1951-1955

The Ohio River Valley Water Sanitation Commission, Cincinnati, Ohio, 1957. 112 pp. The assembled data include records of physical and chemical parameters at 16 sampling points on the Ohio River and at 6 sampling points on its tributaries. OR 57-8

1958

MD58-1 QUARTERLY REPORTS OF COAL ADVISORY COMMITTEE TO THE OHIO RIVER VALLEY WATER SANITATION COMMISSION, FELLOWSHIP NO. 370-4

Braley, S. A., Mellon Inst., 4 Quarterly Repts., 1958. The activity on the project is summarized for each quarter. OR 58-35

MD58-2 PREVENTING STREAM POLLUTION

Cook, L., Mining Congr. J. 44 (1), 62-64 (1958). The Ohio Reclamation Association program of control of acid pollution of water is generally accomplished by segregating the sulfur-bearing material and covering with earth or water to eliminate contact with air. OR 58-2

MD58-3 SOME CONSIDERATIONS IN WATER POLLUTION FROM BITUMINOUS COAL

Hall, E. P. and Hebley, H. F., Unpublished report, 1958. 7 pp. The sources of acid mine water and the chemical mechanics of acid production are discussed. There are also comments on coal preparation sludge and washery water. OR 58-5

MD58-4 PRACTICAL CONTROL MEASURES TO REDUCE ACID MINE DRAINAGE

Hert, O. H. (Ind. Bd. Health), Eng. Ext. Ser. No. 96, Purdue Univ., Proc. 13th Ind. Waste Conf. 1958. pp 189-193. Control measures and acid mine drainage control projects undertaken by Indiana Coal Association, working with the State Board of Health and the Indiana Stream Pollution Control Board, have mainly been concerned with reducing drainage from surface mined land. OR 58-41

MD58-5 OHIO RIVER VALLEY WATER SANITATION COMMISSION - TENTH ANNUAL REPORT

Cincinnati, Ohio, 1958. 32 pp. Graphic and tabular analysis is presented of the progress being made in control and treatment of industrial and municipal wastes. The report discusses the various projects being supported by the Commission. OR 58-12

MD58-6 PENNSYLVANIA PLANT LOCATION FACTORS - REPORT NO. 3 INDUSTRIAL WATER SUPPLIES IN PENNSYLVANIA

Patterson, J. A., Pa. Dept. Commerce, Ind. Dev. Bur. (1958). 88 pp. This report presents in summary form Pennsylvania's basic water data most commonly used by industries in evaluating areas for plant location. The effect of mine drainage is evident in the values for pH of a number of streams listed in the appendix. OR 58-13

MD58-7 ACID DRAINAGE CONTROLS COMING, HANDWRITING ON THE WALL...

Raleigh, W. A., Jr., Coal Age 63 (6), 72-77 (1958). The ORSANCO resolution of January 15, 1958, is reproduced in this article, together with an assessment of its effect on the coal industry in the Ohio River Valley, and a discussion of the background of ORSANCO's action. Some of the methods for acid mine drainage control are outlined briefly. OR 58-33

MD58-8 REPORT OF PROGRESS, 1957-58

W. Va. State Water Comm., 1958. 31 pp. Abatement of pollution from coal washery water and acid mine drainage is described on pages 24-29. OR 58-11

MD58-9 WATER-POWERED DEVICE TREATS ACID WATER AUTOMATICALLY

Coal Age 63 (3), 148 (1958). The Letts automatic limer manufactured by the Shirley Machine Company of Pittsburgh neutralizes acid mine water by adding lime with gravity flow. A rough irregular discharge ditch is recommended to provide mixing action. OR 58-42

MD58-10 WE CAN CONTROL ACID MINE WATERS

Spring Meet., Interstate Comm. Potomac River Basin, Bedford, Pa., May 8-9, 1958. 41 pp. Condensations of the talks presented at this meeting are included in this booklet. Three panel discussions were held. The first related to Pennsylvania's program for the control of acid mine wastes. The subject of the second panel

MD58-10 (continued)

discussion was acid drainage control in other states and in industry. The third panel discussion was on research needs--acid mine water. OR 58-31

MD58-11 WEST VIRGINIA'S CLEAN STREAMS PROGRAM - PRESENT AND FUTURE

Wright, B., Presented W. Va. Conf. Water and Related Natural Resour., 1958. 7 pp. This is a resumé of the activity and responsibilities of the State Water Commission in four areas: (1) Municipal, (2) Industrial, (3) Coal Washery Wastes and (4) Acid Mine Drainage. OR 58-8

1959

MD59-1 A BIOLOGICAL SURVEY OF LITTLE SEWICKLEY CREEK

Consulting Biologists, Rept. to Consolidation Coal Co., Dec. 8, 1959. 10 pp.+ The biological nature of the stream is discussed in detail. The stream is polluted with coal silt and with domestic sewage and other organic loading. Although the pH was alkaline at the time of sampling, the effect of sporadic acid slugs was noted in the limited biological productivity of the stream. OR 59-21

MD59-2 QUARTERLY REPORTS OF COAL ADVISORY COMMITTEE TO THE OHIO RIVER VALLEY WATER SANITATION COMMISSION, FELLOWSHIP NO. 370-5

Braley, S. A., Mellon Inst., 4 Quarterly Repts., 1959. 16 pp. The quarterly reports for 1959 noted areas of work under the fellowship. In the second and third quarterly reports, under the subject Experimental Deep Mine and Continuous Pumping, data on conditions of streams receiving mine discharge illustrate the effects of seasonal precipitation. OR 59-46

MD59-3 WHAT IS YOUR MINE-WATER QUALITY?

Braley, S. A., Mechanization 23 (8), 69 (1959). Suggestions are given for determining the quality of water discharged from mines. OR 59-19

MD59-4 MAGNESIAN HALOTRICHITE FROM VINTON COUNTY, OHIO

Brant, R. A. and Foster, W. R., Ohio J. Sci. 59 (3), 187-192 (1959). Material found during a study of acid waters issuing from coal mines has been demonstrated to be a member of the pickeringite-halotrichite family. The deposition of the halotrichite appears to be a matter of the evaporation of an aqueous solution of ferrous and aluminum sulfates with or without an excess of sulfuric acid. In general the sulphate ions are derived from the oxidation of pyritic material. OR 59-33

MD59-5 HUTCHISON MINE - A PROBLEM IN COAL MINE-DRAINAGE

Hall, E. P. and Rozance, J. L., AIME Joint Meet. Coal Div., Ind. Miner. Div., Bedford Springs, Pa., Sept. 1959. Preprint No. 59F309. 7 pp. This resume of water drainage conditions in a mine typical of the Pittsburgh area is presented to illustrate some of the problems and difficulties caused by water drainage in some coal mining operations, and to point out that these problems must be considered and overcome if coal is to be mined. OR 59-14

MD59-6 WHAT PRICE STREAM POLLUTION?

Hebley, H. F., Mechanization 23 (9), 61-62 (1959). The bituminous coal industry contributes two main sources of pollution to streams, acid mine drainage and suspended solids from preparation plants. Although much research has been done on acid mine drainage no satisfactory solution to the problem is yet available. On the other hand the removal of suspended solids can be accomplished effectively. Coal mine operators are urged to collect data on effluents in order to deal with pollution. OR 59-34

MD59-7 SURVEY OF FERROUS-FERRIC CHEMICAL EQUILIBRIA AND REDOX POTENTIALS

Hem, J. D. and Cropper, W. H., U.S. Geol. Surv. Water-Supply Paper No. 1459-A (1959). 31 pp. The report provides a brief introduction to theoretical aspects of dilute aqueous solutions that contain iron, affords a better basis for understanding the chemical principles which control such solutions, and illustrates the use of theory to explain observed characteristics of natural water. OR 59-11

MD59-8 THE BITUMINOUS COAL OPEN PIT MINING INDUSTRY IN PENNSYLVANIA

Hohnka, L. C., Central Pa. Open Pit Mining Assoc., Philipsburg, Pa., 1959. The Bituminous Coal Open Pit Mining Conservation Act and the Mine Drainage Laws relative to acid mine drainage and industrial wastes from coal mines are summarized. The record of the industry in reclamation and statistics covering the economics of the industry are included. OR 59-4

MD59-9 STUDIES ON AN AUTOTROPHIC BACTERIUM OXIDIZING FERROUS IRON AND ELEMENTAL SULFUR IN ACID MEDIA

Kinsel, N. A., Ph.D. Thesis, Univ. Pittsburgh, 1959. 52 pp. The isolation and characterization of an obligate, autotrophic bacterium oxidizing both ferrous iron and elemental sulfur in acid media is described. OR 59-47

MD59-10 THE INFLUENCE OF BACTERIA ON THE FORMATION OF ACID MINE DRAINAGE

Leathen, W. W. (Mellon Inst.), AIME Joint Meet. Coal Div., Ind. Miner. Div., Bedford Springs, Pa., 1959. Preprint 59F305. 8 pp. The studies leading to the identification of both iron oxidizing bacteria and sulfur oxidizing bacteria and the understanding of their role in the formation of acid mine waters are reviewed. It is pointed out that the widespread distribution of the organisms in soil would preclude the successful sterilization of mines against bacterial activity. OR 59-48

MD59-11 POTOMAC RIVER WATER QUALITY NETWORK - COMPILATION OF DATA, WATER YEARS 1958-1959

Interstate Comm. Potomac River Basin, Washington, D.C., 1959. (76 pp.) Comprehensive analyses of samples from stations in the Potomac River Basin for flow, temperature, turbidity, alkalinity, pH, dissolved O_2 , BOD, bacteria and solids are tabulated. OR 59-1

MD59-12 STUDIES ON THE CHEMOAUTOTROPHIC IRON BACTERIUM *FERROBACILLUS FERROOXIDANS*: I. AN IMPROVED MEDIUM AND A HARVESTING PROCEDURE FOR SECURING HIGH CELL YIELDS

Silverman, M. P. and Lundgren, D. G. (Syracuse Univ.), J. Bacteriol. 77 (5), 642-647 (1959). The increased iron content of the new medium resulted in increased cell numbers. The strain used was supplied by W. W. Leathen. His observations on the morphology of the bacterium were confirmed, but not his observations of its mobility. OR 59-7

MD59-13 STUDIES ON THE CHEMOAUTOTROPHIC IRON BACTERIUM *FERROBACILLUS FERROOXIDANS*: II. MANOMETRIC STUDIES

Silverman, M. P. and Lundgren, D. G. (Syracuse Univ.), J. Bacteriol. 78 (3), 326-331 (1959). The physiological properties and iron-oxidizing system of the bacterium were studied manometrically using intact cells. Ferrous ions were oxidized unusually rapidly. The optimal conditions for the iron-oxidizing system were pH 3.0-3.6 and temp. 37°C. The effect of increased concentration of ferrous ions and the presence of other ions is discussed. OR 59-8

1960

MD60-1 LIMITS OF THE NATURAL ENVIRONMENT IN TERMS OF pH AND OXIDATION-REDUCTION POTENTIALS

Baas Becking, L. G. M. (1), Kaplan, I. R. (2), and Moore, D. (1) [(1) Australian Bur. Miner. Resour. (2) UCLA], J. Geol. 68 (3), 243-284 (1960). Chemical reactions in the natural environment are discussed from the point of view of how these reactions both limit the existence of organisms and contribute to the effect of the organisms on their environment. A discussion of the pH and Eh of mine water is included. Also relevent to the mine drainage problem are the characterizations of iron bacteria and thiobacteria. OR 60-83

MD60-2 THE OXIDATION OF PYRITIC CONGLOMERATES

Braley, S. A., Mellon Inst., Spec. Rept. to Coal Ind. Advisory Comm. to Ohio River Valley Water Sanit. Comm., Res. Proj. No. 370-6 (1960). 32 pp. The reaction of naturally occurring sulfuritic materials, found in coal measures and the adjacent geologic strata, with atmospheric oxygen is investigated. The data explain the formation of mine acid and the secondary reactions which result in the wide variation in the composition of mine effluents. The effect of time on acid formation and changes in composition of water extracts is demonstrated. OR 60-79

MD60-3 THE OXIDATION OF PYRITIC CONGLOMERATES

Braley, S. A., Reprinted from Ind. Wastes, Aug. 1960. 3 pp. Work on the basic mechanism for the production of acid mine wastes is reported. Two reactions are presented, one for the oxidation of FeS_2 by dry air, the other the reaction of FeS_2 in the presence of oxygen and water. The dry oxidation proceeds to $FeSO_4$ and SO_2. In the presence of moisture $FeSO_4$ and H_2SO_4 are the end products. A most interesting aspect of these reactions is the effect of lime when it is present in the conglomerate. This information tends to explain the question developed by the absence of free acid in the waste although sulfuric acid is produced by the reaction. Details of the experimental work carried out to establish these reactions are given. (From Editor's Note) OR 60-1

MD60-4 PROPOSED RESEARCH PROGRAM FOR 1961 FOR THE ACID MINE-DRAINAGE RESEARCH PROJECT

Braley, S. A., Mellon Inst., Rept. to Coal Ind. Advisory Comm. to Ohio River Valley Water Sanit. Comm., Res. Proj. No. 370-7 (1960). 8 pp. Continuation of four major long range experiments which were already underway and the establishment of two additional long range research projects were recommended. One new project is intended to explore and evaluate the dissolved solids found in mine drainage and the other is intended to work toward developing methods for predicting the acid producing potential of various soil strata. OR 60-74

MD60-5 QUARTERLY REPORT OF COAL ADVISORY COMMITTEE TO THE OHIO RIVER VALLEY WATER SANITATION COMMISSION, RESEARCH PROJECT NO. 370-6

Braley, S. A., Mellon Inst., Quarterly Repts., 1960. 10 pp. These quarterly reports are on work progress, including experimental work on improving mine drainage. The third report gives data collected on quality of discharged mine water, showing the successful use of rapid and complete removal of water and also of mine flooding. OR 60-81

MD60-6 THE ECONOMIC ASPECTS OF THE WATER POLLUTION ABATEMENT PROGRAM IN THE OHIO RIVER VALLEY

Bramer, H. C., Ph.D. Thesis, Univ. Pittsburgh, 1960. 207 pp. The short section (pp 115-118) on mine drainage abatement is related to the costs of mine sealing since the cost of neutralization is presumed to be prohibitive. OR 60-54

MD60-7 ACID MINE DRAINAGE MANUAL

Brant, R. A. and Moulton, E. Q., Ohio State Univ., Eng. Expt. Sta., Bull. 179 (1960). 40 pp. This is a well illustrated and thorough discussion of the formation and steps towards abatement of acid mine drainage. OR 60-36

MD60-8 IMPOUNDING AND LIMING ACID MINE DRAINAGE

Cole, V. W., Ind. Wastes 5 (1), 10-11 (1960). Impoundments constructed below sources of acid mine drainage can be treated with lime to maintain an alkaline pH at a much lower cost than other methods of treatment. Lake Alma and Lake Hope in Vinton County, Ohio are examples of the efficacy of this treatment. OR 60-65

MD60-9 OXIDATION OF PYRITE BY IRON SULFATE SOLUTIONS

Garrels, R. M. and Thompson, M. E., Am. J. Sci. 258A, 57-67 (1960). Oxidation of pyrite samples from three localities by acid ferric sulfate solutions took place at markedly different rates. Both ferric and ferrous ions are rapidly adsorbed onto the surface of pyrite with oxidation taking place at ferric ion adsorption sites. Trace elements found in the pyrite samples seemed to have little effect on the oxidation rates. OR 60-52

MD60-10 CHEMICAL ANALYSIS OF COAL MINE-DRAINAGE

Hall, E. P. (Res. Consultant), Consolidation Coal Co., Pittsburgh, Pa., 1960 (Revised 1962). 29 pp. Methods of analysis of constituents of coal mine drainage--acidity, alkalinity, aluminum, calcium, chloride, iron, magnesium, manganese, sulfate--are outlined. The analyses have been, in many cases, modified to overcome mutual interference of the various substances found in mine drainage. Also discussed are acid formation rate, hardness, pH determination, and flow measurement. OR 60-82

MD60-11 THE SHEBAN PROJECT

Hall, E. P., Cook, L., Braley, S. A., Brant, R. A., Riley, C. V., Fisher, E. H., and Williams, N. E., Unpublished Progress Report to October, 1960. The Sheban Project is a cooperative experiment in controlling water pollution by impoundment of water in an abandoned surface mining operation which had in turn been preceded by an underground mining operation. The report covers the first two years of the project, including a year of preliminary studies and a year of impoundment, and is complete to the date of October, 1960. OR 60-35

MD60-12 MINE DRAINAGE CONTROL IN INDIANA

Hert, O. H., J. Water Pollut. Contr. Fed. 32, 505-508 (1960). This is a review of the problems of drainage from surface mine operations and the program to reduce the effects of acid discharge in Indiana. Segregating and covering acid producing material will help to minimize the problem. OR 60-22

MD60-13 THE BIOLOGY OF POLLUTED WATERS

Hynes, H. B. N., Toronto: University of Toronto Press, 1971. 202 pp. Chapter 5, Effluents and Chemistry; Chapter 6, Physical and Chemical Effects of Effluents on Rivers; and Chapter 8, Biological Effects of Simple Deoxygenation and Suspended Solids, are especially relevant to the problem of acid mine drainage. In Chapter 13, The Biological Assessment of Pollution, perspective is given to the biological and chemical variables and interrelationships of polluted waters, including mine drainage. OR 60-80

MD60-14 NEW SULFUR OXIDIZING IRON BACTERIUM: FERROBACILLUS SULFOOXIDANS SP. N.

Kinsel, N. A. (Univ. Pittsburgh), J. Bacteriol. 80, 628-632 (1960). This recently

MD60-14 (continued)

identified organism, Ferrobacillus sulfooxidans, was isolated from coal-mine water from Western Pennsylvania and is characterized by its ability to derive energy by oxidizing both elementary sulfur and ferrous iron. OR 60-40

MD60-15 A FIELD STUDY IN ACID MINE DRAINAGE

Lucas, J. R. (The Ohio State Univ.), Ann. Meet. AIME, New York, N. Y., 1960. Preprint 60F35. 13 pp. A small isolated mine producing significant amounts of drainage, and located just above Lake Hope State Park in Vinton County, Ohio was chosen for field study. Before the mine was sealed the acid drainage was monitored over several months and petrographic and chemical analyses were made of the coal. The mine seal, for which the design is shown, permitted both air and water sealing. Provision was made for sampling water and atmosphere in the mine. Results of the short test period indicate that acid production can be reduced by mine sealing. OR 60-87

MD60-16 THE MINING GUIDEBOOK: HANDLING MINE WATER

Coal Age 65 (7), 254-256 (1960). Among topics discussed are diversion and gravity flow; pumping; planning pipelines; and considerations of acid water. OR 60-5

MD60-17 POTOMAC RIVER WATER QUALITY NETWORK - COMPILATION OF DATA, WATER YEAR 1960

Interstate Comm. Potomac River Basin, Washington, D.C., 1960. 35 pp. Comprehensive analyses of samples from stations in the Potomac River Basin on flow, temperature, turbidity, alkalinity, pH, dissolved, O_2, BOD, bacteria and solids are tabulated. OR 60-8

MD60-18 ACID-DRAINAGE CURBS ARE HERE

Raleigh, W. A., Jr., Coal Age 65 (4), 80-84 (1960). ORSANCO Resolution 5-60 is stated. Present practice in acid-drainage control and present understanding of acid formation are discussed. The Resolution calls for water and refuse handling practices to minimize pollution and for regulation of mine drainage discharge. OR 60-2

MD60-19 THE ECOLOGY OF WATER AREAS ASSOCIATED WITH COAL STRIP-MINED LANDS IN OHIO

Riley, C. V., Ohio J. Sci. 60 (2), 106-121 (1960). The data presented in this paper are part of an extensive study conducted from August 1946 to October 1951, and from additional research conducted from June 1952 to October 1957. The objectives of the study were: to identify and determine ecological relations of plants and animals inhabiting the water and its environs, to determine which materials of the overburden were important contributors to the formation of acid present in many strip ponds, and to determine practical methods of managing the watershed and the ponds. (From author's Objectives) OR 60-73

MD60-20 THE ELIMINATION OF SULFUR FROM COAL BY MICROBIAL ACTION

Rogoff, M. H., Silverman, M. P., and Wender, I. (U.S. Bur. Mines), ACS Div. Gas and Fuel Chem. Preprints, New York, N. Y., Sept. 1960. pp 25-36. The role of microorganisms in the oxidation of sulfur-containing materials is presently under study. Mine waters contain iron-, sulfur-, and thiosulfate-oxidizing and sulfate-reducing bacteria. A rapid manometric method for studying the biological oxidation of pyrites has shown that pyrite oxidation is increased 8 to 13 fold over controls in the presence of Ferrobacillus ferrooxidans; Thiobacillus thiooxidans apparently plays no role in pyrite oxidation. The rate of pyrite oxidation in the presence of the bacteria is affected by particle size of the crushed material, crystalline form

MD60-20 (continued)

of the iron disulfides, pH and other factors. Other experiments are concerned with oxidation of organically combined sulfur by microorganisms. Problems inherent to bacterial coal desulfurization and their role in acid mine drainage formation and treatment are discussed. (Authors' abstract) OR 60-33

MD60-21 CONTROLLED MINE WATER DRAINAGE

Steinman, H. E., Ind. Water and Wastes 5, 201-203 (1960). The measures applied by the Jones and Laughlin Steel Company for the control and disposal of acid mine drainage in their Vesta mines are discussed. A wide variety of controls used include air sealing of abandoned workings, collection of drainage in sumps, controlled pumping, blending of acid and alkaline waters, and the the use of pipes where possible instead of open ditches. Waste waters from the coal preparation plant are impounded for solids removal. OR 60-11

MD60-22 AN OPERATOR'S APPROACH TO MINE WATER DRAINAGE PROBLEMS AND STREAM POLLUTION

Steinman, H. E., Mining Congr. J. 46 (7), 70-73 (1960). Recommendations to minimize mine acid formation for all new working areas at J & L Vista-Shannopin Coal Div. are based on the Sanitary Water Board and Mellon Institute program. Drainage from mined-out areas continues to be a problem. Where possible, acid seepage is combined with alkaline water for neutralization before pumping to the surface. If this is not possible the acid mine water is pumped to a discharge point on a stream already contaminated. The level of water in pool in an abandoned mine was lowered with a resulting reduction in the amount of iron going into a stream. The construction of slime disposal ponds at the company's preparation plant has also contributed to improvement of the water quality in streams serving these areas. OR 60-56

MD60-23 STRIPPING FOR PROFIT

Coal Age 65 (7), 267-286 (1960). This is a general article which covers stripping operations from the preliminary study of the land and coal through drainage. Brief discussions of prevention of inflow, gravity drainage, and pumping are included. Two treatment plants for neutralizing acid-water with limestone are described briefly. OR 60-3

MD60-24 WATER RESOURCES ACTIVITIES IN THE UNITED STATES - POLLUTION ABATEMENT

86th Congress, 2nd Session, U.S. Senate, Select Comm. National Water Resour., Comm. Print No. 9, 1960. 38 pp. This Public Health Service Report includes a statement of the problem of acid mine drainage with suggestions for dealing with it, and notes on the effects of mine drainage on the North Branch of the Potomac River and on the Ohio River and its tributaries. OR 60-34

MD60-25 PUMPING AND PUMPING PROBLEMS IN MINES

Woodley, J. N. L., Trans. Inst. Min. Eng. 119 (11), 685-697 (1960). The general operating principles of positive displacement, centrifugal pumps, and submersible pumps are presented. Problems which arise from operation in mine water which is acidic or which contains high proportions of suspended solids are discussed. OR 60-30

1961

MD61-1 ANNUAL REPORT OF PROGRESS FOR THE FISCAL YEAR 1960-1961

W. Va. State Water Resour. Bd., Charleston, W. Va., 1961. 43 pp. The status of coal washery waste treatment facilities is tabulated. Acid mine water pollution surveys were made on Jones Creek watershed, and on Snowy Creek and Laurel Run, tributaries of the Youghiogheny River. OR 61-73

MD61-2 QUARTERLY REPORT OF COAL INDUSTRY ADVISORY COMMITTEE TO THE OHIO RIVER VALLEY WATER SANITATION COMMISSION RES. PROJ. 370-7

Braley, S. A., Mellon Inst., 1st Quarterly Rept., 1961. 5 pp. This report on status of long range pumping programs includes analysis of samples taken from augur drilling of strip operation high walls, exposed to air for six months. Results support the hypothesis that the contamination of water by acid and other contaminants is primarily the result of the oxidation of pyritic or sulfuritic materials. OR 61-2

MD61-3 QUARTERLY REPORT OF COAL INDUSTRY ADVISORY COMMITTEE TO THE OHIO RIVER VALLEY WATER SANITATION COMMISSION RES. PROJ. 370-7

Braley, S. A., Mellon Inst., 2nd Quarterly Rept., 1961. 4 pp. Very brief reports on the long range projects of the fellowship are presented. In addition, a table which illustrates a relationship between acidity and the concentration of manganese in waters of various types is included. OR 61-81

MD61-4 ROBOT MONITOR KEEPS WATCH ON RIVER CONDITIONS

Cleary, E. J. and Kline, W. L., Public Works 92, 73-75 (1961). Water quality surveillance of the Ohio River is to be augmented by a system of automatic monitoring installations with associated telemetering equipment terminating at Cincinnati. The prototype ORSANCO robot monitor provides for the measurement of pH, chloride ion concentration, specific conductance, dissolved oxygen concentration, oxidation-reduction potential, temperature, and solar radiation. An automatic sampler is included to permit storing a water sample which shows abnormal quality. OR 61-4

MD61-5 CORROSION OF METALS IN MINE WATERS

Natl. Coal Bd., Sci. Bul. No. 8, 10-15, Spring 1961. Mine waters are classified into five types. The pH and mineral characteristics of each type are identified and the corrosive effects of each are described. OR 61-75

MD61-6 DEEP-MINING GUIDEBOOK: MINE DRAINAGE AND PUMPING

Coal Age 66 (7), 211-213 (1961). General mine water handling problems are discussed. Acid control is one of the important items in setting pumping schedules from deep mines. OR 61-10

MD61-7 GREEN CUCUMBER VALLEY PAINTED ORANGE

Water, Land and Life 3 (3), 13 (1961). The Western Pennsylvania Conservancy comments on a surface mining operation which opened up an abandoned mine, releasing large quantities of acid water into Little Cucumber Run. OR 61-37

MD61-8 CONTROL OF WATER-CARRIED WASTES FROM THE COAL INDUSTRY

Hall, E. P., Presented, Ky.-Tenn. Sect. Water Pollut. Contr. Fed., Louisville, Ky., Sept. 12, 1961. 9 pp. The principal water-borne waste of the coal industry is suspended solids from coal preparation operation, commonly referred to as black water. The control of these solids can be accomplished through effective sedimentation and clarification, which removes the solids from the water. The problem of acid mine drainage is being vigorously investigated and definite progress has been made toward finding solutions to it. The problem of sedimentation from the erosion

MD61-8 (continued)

of stripped areas is presently being defined and reclamation activities to minimize it are being carried out effectively. OR 61-19

MD61-9 ANALYSIS OF FUNDAMENTALS OF ACID MINE DRAINAGE: A BASIS FOR FUTURE INVESTIGATION

Hanna, G. P., Jr., Brant, R. A., Lucas, J. R., Randles, C. I., and Smith, E. E., The Ohio State Univ. Eng. Expt. Sta., Final Rept., Proj. EES-175, to Ohio River Valley Water Sanit. Comm., 1961. 76 pp. The mine drainage problem is reviewed with emphasis on the chemistry of the sulfide to sulfate reaction; the role of bacteria; and the related mineralogy, geology, and hydrology. Recommendations for further research are made. OR 61-22

MD61-10 AT CUCUMBER FALLS MINE ACID DOES ITS DIRTY WORK

Jones, F., Pittsburgh Press, (11/12/61). Pictures of the effect of a sudden flow of acid mine water into a stream are the predominant feature of this article. OR 61-44

MD61-11 PURIFICATION AND TREATMENT OF PIT WATERS OF VERY HIGH IRON CONTENT

Kadner, W., Vom Wasser, Issue 28, 131-144 (1961). National Coal Bd. Trans. A.2392/FWH. Purification of water containing iron is effected by treatment with 10 percent lime milk and dewatering of the sludge. In the East German Schwarze Pumpe program, iron is removed by lime treatment and dewatering the resulting sludge. Data are given for flow rates and quantities of treatment chemicals. OR 61-57

MD61-12 HYDROLOGIC PROCESSES DILUTING AND NEUTRALIZING ACID STREAMS OF THE SWATARA CREEK BASIN, PENNSYLVANIA

McCarren, E. F., Wark, J. W., and George, J. R., U.S. Geol. Surv., Prof. Paper No. 424-D, Geol. Surv. Res., 1961. pp D-64--D-67. Chemical analyses of drainage from six anthracite mines in the basin and of several streams in the area indicate a potential for dilution and neutralization of mine wastes by stream waters. OR 61-84

MD61-13 PINE CREEK—THE STORY OF A RECLAIMED STREAM

Central Pa. Open Pit Mining Assoc., 1961. 4 pp. Pine Creek, a stream polluted by acid mine drainage from abandoned deep mines, has been reclaimed by open pit coal recovery reclamation of the pits, and subsequent planting. OR 61-6

MD61-14 PROFITABLE STRIPPING: DRAINAGE

Coal Age 66 (7), 231 (1961). This general discussion of water drainage in surface mine operations deals with preventing inflow, gravity drainage, pumping, and neutralizing water. OR 61-12

MD61-15 QUALITY COAL PREPARATION: WATER HANDLING

Coal Age 66 (7), 244-246 (1961). The treatment of wash water to prevent loss of coal to refuse and to conform to stream-pollution regulations is discussed. OR 61-11

MD61-16 RIVER-QUALITY CONDITIONS DURING A 16-WEEK SHUTDOWN OF UPPER OHIO VALLEY STEEL MILLS

Ohio River Valley Water Sanit. Comm., Cincinnati, Ohio, 1961. 39 pp.+ During a shutdown of the upper Ohio Valley steel mills the phenols, manganese, alkalinity, fluorides, and temperature all decreased. Only minor changes in hardness, sulfates, and dissolved solids were observed demonstrating the impact of mine drainage in

MD61-16 (continued)

these areas. On the Mahoning River, where there is little mine drainage, the decrease in these qualities was greater. OR 61-23

MD61-17 AUTOMATION OF MINE-DRAINAGE INSTALLATIONS

Rutman, R. A., Reprint from "Automation in the Coal and Ore Mining Industries," Proc. Sci. Tech. Conf., Kiev (1961). Jerusalem: Israel Program for Scientific Transl. (1965). The changes in design of automatic equipment for mine drainage are listed. OR 61-65

MD61-18 BACTERIAL OXIDATION OF PYRITIC MATERIALS IN COAL

Silverman, M. P., Rogoff, M. H., and Wender, I., Applied Microbiol. 9 (6), 491-496 (1961). Applicability of the manometric method for studying the oxidation of pyritic material in the presence of bacteria has been demonstrated. Resting cells of Ferrobacillus ferrooxidans accelerated the oxidation of coal pyrites and coarsely crystalline marcasite, but were inactive on coarsely crystalline pyrite. Resting cells of Thiobacillus thiooxidans were inactive on all pyrites tested. Oxidation rates in the presence of Ferrobacillus were increased by reducing the particle size of pyritic samples, and in one case, by removing the $CaCO_3$ from a calcite containing sample. (Authors' abstract) OR 61-35

MD61-19 OXYGENATION OF FERROUS IRON

Stumm, W. and Lee, G. F., Ind. Eng. Chem. 53 (2), 143-146 (1961). This study of the reaction between ferrous iron and oxygen emphasizes the role oxygenation catalysts play in iron removal from natural waters. The experimental work indicates that the oxidation reaction may be the controlling factor up to pH 7 while in the more alkaline range flocculation may be the controlling step. OR 61-64

1962

MD62-1 ACID MINE DRAINAGE

U.S. Public Health Serv., Rept. to U.S. House Representatives, Comm. Public Works, 87th Congr., 2nd Session, House Comm. Print No. 18 (1962). 32 pp. This report, the basis for recommendations for legislation, is a comprehensive review of the history, chemistry, and geology-hydrology of the acid mine drainage problem as well as of control measures and research needs. OR 62-113

MD62-2 ACID NEUTRALIZING SERVICE CORPORATION DESIGNS A KEY TO PREVENTING STREAM POLLUTION

Outdoor People, Apr. 5, 1962. p 14. In a demonstration, Rochez Brothers, Inc. mobile neutralization unit treated Little Scrubgrass Creek water having pH 4.2 and discharged water with pH 7.4. The equipment will handle up to 400 gpm of water with a maximum lime use of three pounds per hour. OR 62-107

MD62-3 CONTROL OF COAL MINE DRAINAGE

Braley, S. A., Presented, 76th Ann. Meet. Coal Mining Inst. America, Pittsburgh, Pa., Dec. 13-14, 1962. 9 pp. The principles of acid mine drainage control as proposed by ORSANCO are discussed. Results of work in the past are considered critically. OR 62-72

MD62-4 AN EVALUATION OF MINE SEALING

Braley, S. A., Mellon Inst., Spec. Rept. to Coal Ind. Advisory Comm. to Ohio River Valley Water Sanit. Comm., Res. Proj. No. 370-8, 1962. 33 pp.+ This report presents a discussion of the theory of mine sealing and the criteria upon which evaluation of the procedure can be made. Data collected on a group of selected isolated

MD62-4 (continued)

mines before sealing and for a period of years after sealing are given. The seasonal effects on acid production and sealed mine atmosphere are shown. The conclusions are that mine sealing is ineffective for the reduction of acid discharged from drift mines. It does not reduce the oxygen content of the mine atmosphere. The sealing of two mines whose discharge entered a clean mountain stream did not beneficiate the stream. OR 62-10

MD62-5 FLOODING OF A DEEP MINE

Braley, S. A., Mellon Inst., Spec. Rept. to Coal Ind. Advisory Comm., Ohio River Valley Water Sanit. Comm., Res. Proj. No. 4370-8, 1962. 10 pp.+ The results of a study of the water discharge of a sealed and abandoned mine are presented. The conclusion is "that complete abandonment of deep mines will ultimately result in beneficiation of the water naturally discharged therefrom as a result of flooding irrespective of the air sealing procedure." OR 62-29

MD62-6 NATURAL BENEFICIATION OF AN ABANDONED MINE

Braley, S. A., Mellon Inst., Spec. Rept. to Coal Ind. Advisory Comm., Ohio River Valley Water Sanit. Comm., Res. Proj. No. 4370-8, 1962. 5 pp. Report on the improvement of water quality of the free flowing discharge from an undistrubed abandoned mine which had not been sealed. The data indicate that the discharge improves measurably without regard to correctional procedures with the passage of time. OR 62-30

MD62-7 A BASIC STUDY OF ACID MINE DRAINAGE FORMATION

Clark, C. S., M.S. Thesis, Johns Hopkins Univ., 1962. 96 pp. Several aspects of the electrolytic decomposition of iron disulfide materials are theoretically and experimentally explored in the three chapters of this paper. The thermodynamic basis of a number of half-reaction yields a prediction of the anode and cathode reactions in the pyrites corrosion cell. A thermodynamic explanation is offered for the frequent observation that iron-oxidizing bacteria increase the rates of pyrites decomposition and of acid formation. A procedure for theoretically determining the usefulness of a substance as an anodic or cathodic inhibitor is established. Results of the present experiments on inhibitors are essentially the same as those in an earlier study at Johns Hopkins. (From author's abstract) OR 62-51

MD62-8 COAL DIVISION - EASTERN GAS AND FUEL ASSOCIATES - PUMPING AND DRAINAGE

Coal Age 67 (10), 125-127 (1962). Water handling at the company's mines includes keeping water out if possible, taking advantage of gravity flow, employing sufficient pumps, and maintaining the system. The severity of the problem varies from mine to mine. OR 62-41

MD62-9 INFLUENCES OF STRIP MINING ON THE HYDROLOGIC ENVIRONMENT OF PARTS OF BEAVER CREEK BASIN, KENTUCKY 1955-1959

Collier, C. C., et al. Geol. Surv., U.S. Dept. Int., Professional Paper 427-B (1964). 83 pp.+ Surface mining has occurred in about 10 percent of the Cane Branch area since 1955. The Helton Branch area has had no mining activity. A comprehensive comparison of chemical content, flooding characteristics, effect on aquatic life, and on flora and fauna in these areas is presented. OR 62-16

MD62-10 SPEARHEADING THE OHIO VALLEY INTERSTATE MINE DRAINAGE CONTROL

Cook, L., Eng. Ext. Ser. No. 112, Purdue Univ., Proc. 17th Ind. Waste Conf., 1962. pp 543-545. The activity of the Coal Industry Advisory Committee in finding measures for the control of Acid Mine Drainage are discussed. The control measures contained in ORSANCO Resolution 5-60 are outlined. OR 62-26

MD62-11 MINE WATER CONTROL PROGRAM, ANTHRACITE REGION OF PENNSYLVANIA JULY, 1955 - DECEMBER, 1961

Dierks, H. A., Eaton, W. L., Whaite, R. H., and Moyer, F. T., U.S. Bur. Mines, IC 8115 (1962). 63 pp. The report covers 29 mine flood control projects. Essential engineering and cost details for each project are given, together with an evaluation of the effect that the installed facilities have on alleviating the mine water problem as it concerns individual mines and the anthracite industry as a whole. (From authors' abstract) OR 62-24

MD62-12 STRATIGRAPHIC RELATIONS TO ACID MINE WATER PRODUCTION

Hanna, G. P., Jr. (1) and Brant, R. A. (2) [(1) Ohio State Univ., Water Resour. Cent. (2) Ohio Geol. Surv.], Eng. Ext. Ser. No. 112, Purdue Univ., Proc. 17th Ind. Waste Conf., May 1-3, 1962. pp 476-492. The work outlined in this paper has attempted to relate acid formation to various strata. While acid generators do not parallel the oxidation in situ of pyritic materials it is possible through their use to compare oxidation rates and thereby begin to develop a quantitative means of measurement. A diagram of the apparatus used for leaching studies and graphic presentation of the results are included. OR 62-17

MD62-13 A RAPID METHOD FOR THE DETERMINATION OF Fe(III) IN POLLUTED WATERS BY DIRECT TITRATION WITH ETHYLENE-DIAMINE-TETRA-ACETIC ACID (E.D.T.A.)

Hellwig, D. H. R. and van Steenderen, R. A., Water and Waste Treatment, 118-120, Sept./Oct. 1962. The method was found suitable for the determination of iron in natural waters in concentrations as low as one part per million. Zinc above 5 ppm and copper above 0.2 ppm were the only ions which showed interference. Magnesium, manganese, calcium, and aluminum, often found in mine drainage did not interfere in the analysis in amounts tested. OR 62-103

MD62-14 MACHINE NEUTRALIZES MINE ACID

Latham, R., Pittsburgh Press, 49, (3/28/62). Rochez Bros., Inc., of East Pittsburgh, has developed a portable machine which can neutralize mine acid entering streams. The neutralizing unit which can treat 100 gal/min. is made up of a pumping system and a lime dispensing unit which treats the water as it is pumped through the unit. It was demonstrated on a stream with pH 4. OR 62-9

MD62-15 PROGRESS IN CONTROLLING ACID MINE WATER: A LITERATURE REVIEW

Lorenz, W. C., U.S. Bur. Mines, IC 8080 (1962). 40 pp. In connection with its renewed study seeking solutions to problems created by release of acid water from bituminous coal mines, the Bureau of Mines recently surveyed the literature. There are 207 references. OR 62-44

MD62-16 A LYSIMETER FOR STUDYING THE PHYSICAL AND CHEMICAL CHANGES IN WEATHERING COAL SPOIL

Lowry, G. L. and Finney, J. H., Ohio Agr. Expt. Sta., Res. Circ. 113 (1962). 17 pp. The lysimeter described and pictured in this paper was constructed and set up with 20 samples of differing texture and acidity. All samples will be exposed to the same conditions of weather at the same time. Future publications are planned to report the changes in physical and chemical properties of the weathered spoils. OR 62-112

MD62-17 RECONNAISSANCE OF GROUND-WATER RESOURCES IN THE WESTERN COAL FIELD REGION, KENTUCKY

Maxwell, B. W. and Devaul, R. W., U.S. Geol. Surv., Water-Supply Paper 1599, 1962. 34 pp. The availability and quality of the water in the area is described. OR 62-114

MD62-18 NOVEL WATER TREATMENT PLANT INSTALLED AT SMITH MINE

Burns and Mixes (Publ. by Harbison-Walker Refractories Co.) 17 (6), 2-3 (1962). The mine water treatment system at the company's Smith Mine near Ohiopyle, Pa. is described. Water running from the mine, including the face being stripped and the spoil piles, is carried through weirs to two settling ponds. Hydrated lime is fed into the water passing through the weirs according to the pH or the mineral acidity and the volume of water. Some soda ash is added to maintain a permanent pH value. OR 62-108

MD62-19 PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON THE CONTROL OF COAL MINE DRAINAGE

Pa. Dept. Health, Bur. Environ. Health, Publ. No. 4, 1962. 113 pp. Work group sessions and their chairmen are: 1. Law and legislation, William M. Gross; 2. Technical aspects of control of drainage from active mines, Russell S. Klingensmith; 3. Technical aspects of control of drainage from abandoned mines, S. A. Braley; 4. Restoration of areas affected by coal mining, Wilson Wheeler, includes separate papers by L. E. Sawyer, Grant Davis, and M. L. Schaefer; 5. Improvement of acid polluted streams by water resources development, Lester M. Klashman; 6. Administration of mine drainage control programs, L. S. Morgan. Work group reports, summary and discussion of sessions, and specific comments of participants are included in these proceedings. OR 62-73

MD62-20 WATER MANAGEMENT IN COAL STRIP LAND RECLAMATION

Riley, C. V., Kent State Univ., Ohio, 1962. This is an illustrated brochure giving information on pond planning and construction on surface mine areas to give most effective final use of the area. OR 62-23

MD62-21 THE SUSQUEHANNA: A STUDY OF THE RIVER BASIN

The League of Women Voters of Pennsylvania, Harrisburg, 1962. 26 pp. This study examines the history and economic development of the basin and discusses its problems, including drainage from the many active and abandoned coal mines within its boundaries. A map of the Pennsylvania coal fields shows acid streams in red. OR 62-106

MD62-22 YESTERDAY...TODAY AND TOMORROW

Ohio River Valley Water Sanit. Comm., 14th Ann. Rept., Cincinnati, Ohio (1962). 16 pp. The condition of the water in the Ohio River basin in 1962 is contrasted with the conditions found in 1948 when the Ohio River Valley Water Sanitation Compact was inaugurated. Among the improvements are sewage treatment plants, requirements for waste control by industry, and river quality monitoring. The report includes a tabulation of variations in water quality and flow in the Ohio River during 1961. OR 62-105

1963

MD63-1 VARIATIONS IN THE CHEMICAL CHARACTER OF THE SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA

Anderson, P. W., U.S. Geol. Surv., Water-Supply Paper 1779-B, 1963. 17 pp. The influence of streamflow, anthracite and bituminous coal mine drainage, and geology on the chemical quality of the Susquehanna River is discussed in this paper. The sampling pattern of the Harrisburg cross-section indicates that the water from the principal tributaries above Harrisburg does not mix sufficiently to lose its chemical quality identity probably due to the small depth-width ratio and the extreme width of the river. OR 63-18

MD63-2 AUTOMATIC ANALYZERS HELP COMBAT RIVER POLLUTION

Chem. Eng. 70 (3), 49-50 (1963). Automatic analyzers have been set up to continuously feed data on river quality to a headquarters office in Cincinnati. By this means, the Ohio River Valley Water Sanitation Commission is able to detect and characterize any natural or man-made disturbances of the river as soon as they occur. OR 63-19

MD63-3 WATER ECONOMY AND THE POLLUTION PROBLEM IN THE COAL INDUSTRY: REPORTS FROM GERMANY, BELGIUM, GREAT BRITAIN AND THE NETHERLANDS

Bakels, P. S., Reprint from "Re-Use of Water in Industry," London: Butterworth & Co., 1963. pp 31-116. This report summarizes the coal mining industry's water requirements for all purposes. The treatment of water for re-use and the prevention of pollution are also discussed by the chairman and each of the country representatives. This is a good source of information about European water economy and pollution relating to the coal mining industry. It is a report of the Applied Chemistry Section, Water, Sewage, and Industrial Wastes Division, International Union of Pure and Applied Chemistry. OR 63-101

MD63-4 REPORT TO THE SANITARY WATER BOARD ON NORTH BRANCH OF THE SUSQUEHANNA RIVER MINE DRAINAGE STUDY

Boardman, R. M., Rhodes, R. L., and Bellaman, W. C., Pa. Dept. of Health, Div. Sanit. Eng. Publ. No. 5, April 1963. 50 pp.+ The purpose of this report is to review the quality and use of the waters of the North Branch of the Susquehanna River and to discuss possible immediate and long range solutions to the problems caused by acid mine drainage. The report deals primarily with that portion of the river from the mouth of the Lackawanna River to the confluence of the North and West Branches of the Susquehanna River at Sunbury. (From authors' introduction) OR 63-116.

MD63-5 DESCRIPTION OF LETTS AUTOLIMER AND INSTRUCTIONS FOR OPERATION WHEN NEUTRALIZING ACID WATER

Shirley Machine Co., Pittsburgh, Pa., Advertising Sheet, 1963. This lime feeder is designed for neutralizing acid mine water in areas where no power supply is available. OR 63-88

MD63-6 CHEMICAL QUALITY OF SURFACE WATERS IN PENNSYLVANIA

Durfor, C. N. and Anderson, P. W., U.S. Geol. Surv., Water-Supply Paper 1619-W (1963). 50 pp. The main factors influencing chemical quality are aereal differences in geology, urban and industrial development, mining, quarrying, land use, and runoff. In the anthracite coal fields in the northeast and in the bituminous coal fields in the southwest, many streams receive acid mine drainage, which lowers the alkalinity and increases the sulfate content of the waters. OR 63-105

MD63-7 ACID MINE DRAINAGE RESEARCH POTENTIALITIES

Hanna, G. P., Jr., Lucas, J. R., Randles, C. I., Smith, E. E., and Brant, R. A., J. Water Pollut. Contr. Fed. 35 (3), 275-296 (1963). The phenomena associated with the production and abatement of acid mine water are classified into the fundamental areas of chemistry, microbiology, mineralogy, petrology, and geology-hydrology. A planned program of research based on these fundamental areas is outlined. OR 63-25

MD63-8 THE GROWTH AND SURVIVAL OF FISH IN SOME SUSPENSIONS OF SOLIDS OF INDUSTRIAL ORIGIN

Herbert, D. W. M. and Richards, J. M., Int. J. Air Water Poll. 7, 297-302 (1963). Laboratory investigations of the survival rate of rainbow trout in suspensions of solids from a coal-washery waste and from paper manufacture showed no evidence of any lethal effect from up to 200 ppm coal-washery solids, while 200 ppm wood fibre caused a steady mortality. OR 63-29

MD63-9 STRIP MINING, RECLAMATION, AND THE PUBLIC

Jackson, D., Jr., Coal Age 68 (5), 84-95 (1963). This article covers the economics, the problems and the solutions to these problems from the point of view of the Central Pennsylvania Open Pit Mining Association. Improvement of the land, prevention of stream pollution and erosion, and promotion of conservation are all presented as the prime concern of the surface miner. OR 63-2

MD63-10 CHEMICAL GROUTING CUTS WATER FLOW IN COLLIERY DRIFT

Janus, Z. L., Reprinted from Mine & Quarry Mechanisation, 1963. 5 pp. Ground water infiltration was reduced in an Australian mine through the use of cement and chemical grout. The kinds of problems encountered and the solutions applied to various sections are discussed. OR 63-66

MD63-11 MANAGEMENT OF WATER RESOURCES IN THE POTOMAC RIVER BASIN

Johnson, C. J., J. Water Pollut. Contr. Fed. 35 (10), 1318-1324 (1963). In the North Branch of the Potomac, acid mine drainage from coal mines will continue to be a major source of contamination until research provides a solution. State water control agencies are assuming jurisdictional responsibility of mine drainage, a role which state mine departments had played. OR 63-6

MD63-12 LAND CONSERVATION IN PENNSYLVANIA OPEN PIT MINES

Jones, W. G., Mining Congr. J. 49 (10), 52-55 (1963). Surface mining for bituminous coal and reclamation in Pennsylvania result in several benefits including reduction of amount of acid mine drainage from abandoned deep mines, flood control from backfilling mined areas, and planting. OR 63-44

MD63-13 INTRODUCTION TO GEOLOGICAL MICROBIOLOGY

Kuznetsov, S. I., Ivanov, M. V., and Lyalikova, N. N., New York: McGraw-Hill Book Company, Inc., 1963. 252 pp. The role of micro-organisms in the formation of acid from pyrite in the presence of water is recognized as a significant area for study in the acid mine drainage problem. This text discusses the effect of microbial activity on deposits of sulfur, iron, fossil fuels, and related minerals and presents a good review of the literature relating to the subject. OR 63-15

MD63-14 OXIDATION OF COAL MINE PYRITES

Lorenz, W. C. and Tarpley, E. C., U.S. Bur. Mines, RI 6247 (1963). 13 pp. The profound effect of the presence of Ferrobacillus ferrooxidans on the oxidation of pyrites is demonstrated in this paper. Samples from several mines were tested in the presence of ferric iron and ferrous iron with and without bacteria. The results are presented graphically and discussed. OR 63-40

MD63-15 DESCRIPTION OF PHYSICAL ENVIRONMENT AND OF STRIP-MINING OPERATIONS IN PARTS OF BEAVER CREEK BASIN, KENTUCKY

Musser, J. J., U.S. Geol. Surv., Prof. Paper 427-A (1963). 25 pp.+ An investigation of the effects of strip mining for coal on the hydrology of parts of the Beaver Creek basin, McCreary County, Kentucky was begun in 1955. This report describes the topography, drainage, geology, soils, climate, hydrologic environment, and forest vegetation of the study areas and gives a history and description of the mining. (From author's abstract) OR 63-26

MD63-16 ELIMINATING STREAM POLLUTION FROM A COAL PREPARATION PLANT

Noone, W. H., Mining Congr. J. 49 (8), 26-30 (1963). The water clarification plant at the Harewood mine of the Semet-Solvay Division of the Allied Chemical Corporation is described in detail. Suspended solids in the thickener overflow have never

MD63-16 (continued)

exceeded 350 ppm and, in addition, nearly 9 tph of coal is being recovered by water clarification. OR 63-49

MD63-17 OHIO RIVER VALLEY WATER SANITATION COMMISSION - FIFTEENTH ANNUAL REPORT

Cincinnati, Ohio, 1963. 20 pp. As a major step towards the goal of river clean-up, thousands of waste-control facilities have been constructed by municipalities and industry in the valley. The accomplishments of the eight states have merited the Outstanding Civil Engineering Achievement Award of 1963. Planning for further work continues. The ORSANCO Resolution No. 5-60 can be viewed as a forward step in dealing with the acid mine drainage problem. OR 63-57

MD63-18 TREATMENT OF EARTH STRATA CONTAINING ACID FORMING CHEMICALS

Peeler, C. E., Jr. (to Diamond Alkali Company), U.S. Pat. 3,094,846 (June 25, 1963). 6 pp. The use of an alkali metal silicate, including the silicates of sodium, potassium, cesium, and rubidium, to treat acid forming chemicals, notably iron pyrites, in situ is claimed. The alkali metal silicate reacts with the sulfuric acid to form a silica gel dispersed throughout the soil formation. This further tends to encapsulate acid forming materials rendering them inactive. OR 63-93

MD63-19 PROCEEDINGS CONFERENCE IN THE MATTER OF POLLUTION OF THE INTERSTATE WATERS OF THE MONONGAHELA RIVER AND ITS TRIBUTARIES VOL. I, VOL. II, AND VOL. III, PITTSBURGH, PA.

U.S. Dept. HEW, Dec. 17, 1963. 662 pp. These three volumes are the complete proceedings of the conference, including the list of attendees. Presentations from various organizations have already been included in the Mine Drainage Abstracts. See General Index, Monongahela River and Its Tributaries Enforcement Conference. OR 63-118

MD63-20 PROGRESS REPORT: MINE SEALING PROJECT DECKER NO. 3 MINE

U.S. Bur. Mines, Pittsburgh Mining Res. Cent., Sept. 1963. 6 pp. The abandoned mine used to evaluate mine sealing as an abatement procedure is described. A mine map is also included. Information is given on the monitoring equipment installed to record the air and water quality in the mine. Results of analyses of representative air and water samples are tabulated. OR 63-114

MD63-21 REVIEW OF THE CLASSIFICATION OF THE MONONGAHELA RIVER

Pa. Dept. Health, Div. Sanitary Eng., Rept. to Sanitary Water Bd., Aug. 1963. 24 pp.+ Stream quality, water usage, and previous treatment and abatement requirements for the Monongahela River during the period 1940 to 1963 are reviewed for this period. ORSANCO and Pennsylvania industrial and municipal waste discharge and treatment requirements are included in the appendix. OR 63-117

MD63-22 INTERIM REPORT #I ON THE WESTERN MARYLAND pH SURVEY

Rubelmann, R. J., Md. Water Pollut. Contr. Comm., June 10, 1963. 29 pp. The Youghiogheny River, Deep Creek Lake, The Casselman River, The Savage River, Georges Creek, Wills Creek, and the Potomac River North Branch were surveyed to determine the extent of acid mine drainage pollution of the waters of Garrett and Allegany counties. There were 364 stations selected for sampling. pH was chosen as the most practical, easily measured, and reliable indicator of acid pollution. Tabulations of the results of the survey by watershed give station number and location and pH. OR 63-113

MD63-23 STATEMENT

Shaw, J. R. (Chairman, ORSANCO), Conf. of Pollut. of Monongahela River and Its Tributaries, Pittsburgh, Pa., 1963. 30 pp. The activities of ORSANCO since its beginning in 1948 in reducing pollution, especially mine drainage, in the Ohio River and its drainage area are reviewed. OR 63-115

MD63-24 REPORT ON POLLUTION OF THE INTERSTATE WATERS OF THE MONGAHELA RIVER SYSTEM

Sidio, A. D. and Mackenthun, K. M., U.S. Dept. HEW, Robert A. Taft Sanit. Eng. Cent., Cincinnati, Ohio, 1963. 47 pp.+ The study included analyses and observations of chemical, biological, bacteriological, and physical indicators of water quality collected during August and September 1963. The report includes information on the Monongahela main stem and seven tributaries in sections of West Virginia, Maryland, and Pennsylvania. OR 63-24

MD63-25 THE ROLE OF THE MICROBIOLOGICAL FACTOR IN INCREASING THE CORROSIVE AGGRESSIVENESS OF MINE WATER OF THE KIZEL COAL BASIN

Smirnov, V. V. (Perm Univ., USSR), Mikrobiologiya 32 (4), 695-699 (1963). U.S. Dept. Comm., Clearinghouse Transl. No. TT63-41329. This work was done to determine whether the mine water of the Kizel coal basin was acid because of biological activity or chemical activity. Oxidation of pyrite was compared in natural mine waters, mine waters sterilized by various antiseptics, and in sterile mine waters to which cultures of Thiobacillus thiooxidans and Thiobacillus ferrooxidans were added. Biological activity was shown to increase substantially the rate of oxidation of pyrite to sulfuric acid. OR 63-112

MD63-26 STATEMENT ON WATER RESOURCES INVESTIGATIONS IN THE MONONGAHELA RIVER BASIN

Whetstone, G. W., U.S. Geol. Surv., Dec. 1963. 23 pp.+ The overall profile of the Monongahela river basin is discussed. Acid mine drainage, as one of the prime problems of the area, is reviewed thoroughly in relation to the streams in the basin. Extensive tabular data on streamflow and chemical quality of water are presented. OR 63-28

MD63-27 WATER POLLUTION CONTROL IN THE MONONGAHELA RIVER BASIN

Wilbar, C. L., Jr., Pa. Dept. Health, Div. Sanit. Eng., Publ. No. 6, 1963. 86 pp.+ This is the official presentation of the Commonwealth of Pennsylvania at the conference called by the Secretary of U.S. Dept. HEW on Interstate Pollution of the Waters of the Monongahela River and held in Pittsburgh, Dec. 17-18, 1963. The effects of drainage from abandoned and active mines and programs to control mine discharges are included in the discussions of pollution from industrial wastes in the basin. Abandoned mines discharging more than 1000 tons of acid per year and active mines discharging more than 300 tons per year are tabulated. OR 63-23

MD63-28 DISSOLVING LIMESTONE FROM REVOLVING DRUMS IN FLOWING WATER

Zurbuch, P. E., Trans. Am. Fisheries Soc. 92 (2), 173-178 (1963). The treatment of the Otter Creek drainage in the Monongahela National Forest in West Virginia was undertaken using raw limestone in a drum. In the process described, attrition of the limestone aggregate is achieved by tumbling it in a steel drum rotated by the stream flow. Treatment resulted in an increase in pH of the stream which persisted for a short time after treatment ended. OR 63-94

1964

MD64-1 GEOCHEMISTRY OF GROUND WATER IN MINE DRAINAGE PROBLEMS

Barnes, I. and Clarke, F. E., U.S. Geol. Surv. Prof. Paper 473-A (1964). 6 pp. Theoretical geochemistry may provide a basic insight into the causes and effects of acid mine drainage. The elimination of air by mine sealing may not provide a completely satisfactory solution to the problem because there are other causative factors. Indirect neutralization by use of limestone appears to have merit as an interim corrective treatment. OR 64-9

MD64-2 FIELD INVESTIGATION OF MINE WATERS IN THE NORTHERN ANTHRACITE FIELD, PENNSYLVANIA

Barnes, I., Stuart, W. T., and Fisher, D. W., U.S. Geol. Surv. Prof. Paper 473-B (1964). 7 pp. A chemical study of anthracite coal mine waters under field conditions shows that mine-water compositions are controlled by mineral-water reactions. The work was done on oxygen-free (strongly reduced) samples taken from below the surface in open shafts. The electrochemical data are summarized and interpreted in terms of an earlier published theory. OR 64-10

MD64-3 AN OPERATOR LOOKS AT ACID MINE DRAINAGE

Bellano, W., Mining Congr. J. 50 (8), 66-74 (1964). The magnitude of the acid mine drainage problem in the anthracite region of Pennsylvania and the experience of the Glen Alden Coal Co. is reviewed thoroughly. OR 64-18

MD64-4 RECOVERY FROM ACID POLLUTION IN SHALLOW STRIP-MINE LAKES IN MISSOURI

Campbell, R. S., Lind, O. T., Geiling, W. T., and Harp, G. L. (Univ. Mo.), Eng. Ext. Ser. No. 117, Purdue Univ., Proc. 19th Ind. Waste Conf., 1964. pp 17-26. Surface-mine lakes pass through a distinctive series of stages during recovery from acid pollution. The successional pattern is from acid towards alkaline. The rate of recovery from acid pollution varies with the nature of the watershed. Four lakes in Missouri have been studied and compared. OR 64-69

MD64-5 MINE ACID FORMATION AND MINE ACID POLLUTION CONTROL

Clark, C. S. (Johns Hopkins Univ.), Proc. 5th Ann. Symp. Ind. Waste Contr., by Frostburg State College and Md. Water Pollut. Contr. Comm., Frostburg, Md., 1964. pp 50-73. A summary of the existing knowledge of acid formation and of abatement methods is presented. The pollution formation is considered in three stages and abatement methods suitable to each of these stages are outlined. The water quality trends during the past fifty years in the Monongahela-Youghiogheny basin are analyzed. OR 64-50

MD64-6 STATEMENT BEFORE SUBCOMMITTEE ON NATURAL RESOURCES AND POWER, HOUSE GOVERNMENT OPERATION COMMITTEE REGARDING FEDERAL WATER POLLUTION CONTROL

Foresman, F. J., Pittsburgh & Midway Coal Co., May 1964. 6 pp. While it is sound national policy to encourage the control of water pollution, it should remain a problem under local jurisdiction. The problem of pollution from acid mine drainage varies greatly from area to area and should not be dealt with on a general basis. OR 64-32

MD64-7 WATER QUALITY SURVEY OF THE YOUGHIOGHENY RIVER

Hopkins, T. C., Jr. (Md. Water Pollut. Contr. Comm.), Proc. 5th Ann. Symp. Ind. Waste Contr., by Frostburg State College and Md. Water Pollut. Contr. Comm., Frostburg, Md., 1964. pp 17-23. A water quality survey carried out from Nov. 1960 through Jan. 1963 at thirty-two stations is reviewed. Laurel Run, a tributary of Snowy Creek, is the major source of acid mine pollution to the Youghiogheny River. OR 64-47

MD64-8 EXTENT OF ACID MINE POLLUTION IN THE UNITED STATES AFFECTING FISH AND WILDLIFE

Kinney, E. C., Bur. Sport Fisheries and Wildlife, U.S. Dept. Int., Circ. 191 (1964). 27 pp. Data by states on the miles of streams and acres of impoundments which are adversely affected by acid pollution from coal and other mining are presented. OR 64-39

MD64-9 CHEMICAL QUALITY OF SURFACE WATER IN THE WEST BRANCH SUSQUEHANNA RIVER BASIN, PENNSYLVANIA

McCarren, E. F., U.S. Geol. Surv., Water-Supply Paper 1779-C (1964). 40 pp.+ The river is acidic in the upper half of its length, west of Jersey Shore, but the presence of limestone neutralizes the acidic water as it flows downstream. Heavy concentrations of aluminum, iron, manganese, and sulfate are diluted in downstream segments of the river. OR 64-76

MD64-10 ORSANCO - SIXTEENTH ANNUAL REPORT 1964

Ohio River Valley Water Sanitation Comm., Cincinnati, Ohio, 31 pp. The accomplishments of the Commission are reviewed, and the water quality monitoring program is described. OR 64-33

MD64-11 COMPARATIVE LIMNOLOGY OF STRIP-MINE LAKES

Parsons, J. D. (Southern Ill. Univ.), Verh. Internat. Verein. Limnol. 15, 293-298 (1964). Six surface-mine lakes in Missouri were characterized. Three were classified as Type I - Red Lakes, chemically the youngest, with high acid and iron content; and three were classified as Type III - Blue Lakes, which are chemically older and had low iron concentration, lacked turbidity and were homothermous year round. These six lakes were compared to Type II Lakes, transitional between Types I and III, and to Type IV Lakes, chemically the oldest, with least iron and acidity and measurable alkalinity. OR 64-88

MD64-12 PRINCIPLES AND GUIDE TO PRACTICES IN THE CONTROL OF ACID MINE-DRAINAGE

Coal Industry Advisory Committee, Ohio River Valley Water Sanitation Commission, March 1964. This manual reviews the fundamental principles involved in the formation of acid mine-drainage, and is a guide to general control practices. Specific applications are described in the collection of case histories. OR 64-28

MD64-13 AQUATIC LIFE AND THE ACID REACTION

Reppert, R. T. (Univ. Md.), Proc. 5th Ann. Symp. Ind. Waste Contr., by Frostburg State College and Md. Water Pollut. Contr. Comm., Frostburg, Md., 1964. pp 27-49. A program of research on the biology of streams polluted with acid mine water is being conducted by the Natural Resources Institute of the University of Maryland. The findings of their study of the Youghiogheny River in terms of fish population, macro-invertebrate populations, and in situ tolerance studies are presented. OR64-49

MD64-14 A MINE DRAINAGE SURVEY IN WESTERN MARYLAND

Rubelmann, R. J. (Md. Water Pollut. Contr. Comm.), Proc. 5th Ann. Symp. Ind. Waste Contr., by Frostburg State College and Md. Water Pollut. Contr. Comm., Frostburg, Md., 1964. pp 24-26. This is an interim report on a project being conducted by the Maryland Water Pollution Control Commission to pinpoint sources of acid mine drainage in the state. OR 64-48

MD 64-15 CHEMICAL WEATHERING OF STRIP-MINE SPOILS

Struthers, P. H. (Ohio Agr. Expt. Sta.), Ohio J. Sci. 64 (2), 125-131 (1964). Nineteen spoil samples and one soil sample were placed in plastic lysimeters and exposed

MD64-15 (continued)

to natural weather conditions. Natural precipitation provided the moisture which percolated through the samples and was collected in flasks at the bottom. The changing character of the leachates over a four year period was studied. The findings have been summarized and interpreted. OR 64-34

MD64-16 SEWAGE DECOMPOSITION IN ACID MINE DRAINAGE WATER

Wilson, H. A., Hipke, J. L., and Rogers, T. O. (W. Va. Univ.), Eng. Ext. Ser. No. 117, Purdue Univ., Proc. 19th Ind. Waste Conf., 1964. pp 272-280. Under aerobic conditions sewage decomposing bacteria will stabilize the elements that are in organic combination. On the other hand if the natural body of water has been highly polluted with acid mine water the sewage decomposition will depend on the environmental pH. OR 64-67

1965

MD65-1 SELECTED PROPERTIES OF MINE WATER AND THE CHEMICAL ENVIRONMENT WITHIN SOME FLOODED ANTHRACITE MINES

Barnes, I., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 1-9. The study of geologic systems with the purpose of determining the chemical conditions of the natural aqueous solutions in their geologic environments was undertaken on some flooded anthracite mines. The thermodynamic and stoichiometric relationships are complex and interpretation of data is subject to considerable latitude in opinion. OR 65-35

MD65-2 THE ACID MINE DRAINAGE LIBRARY

Beery, W. T. and Glenn, R. A., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 215-218. Acid Mine Drainage Library was established in 1961 at Bituminous Coal Research, Inc., under the sponsorship of the Coal Industry Advisory Committee to ORSANCO. The objective of the program was to make available in one place as much of the literature relating to acid mine drainage and water pollution by the bituminous coal industry as possible. OR 65-56

MD65-3 ACID MINE DRAINAGE

Braley, S. A., Presented before Committee on Fisheries, House of Representatives, Commonwealth of Pennsylvania, Apr. 15, 1965. 19 pp. Arguments are here presented in support of the thesis that no practical, economic means of correcting acid mine drainage are yet available. OR 65-7

MD65-4 THE HUMPHREY PROJECT

Braley, S. A., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 167-173. Data presented on the quality of water discharged from the Humphrey Mine indicate that underground control of the water flowing through a mine can prevent stream pollution. This project has applied water engineering principles to a specific situation with success. OR 65-51

MD65-5 MINE EFFLUENTS - THEIR TREATMENT AND BENEFICIATION

Braley, S. A., Presented, W. Va. Coal Mining Inst., Bluefield, W. Va., April 23, 1965. 10 pp. The mine drainage problem and efforts to abate acid pollution are reviewed. OR 65-128

MD65-6 ACID MINE DRAINAGE POLLUTION CONTROL DEMONSTRATION PROGRAM USES OF EXPERIMENTAL WATERSHEDS

Bullard, W. E., International Assoc. Sci. Hydrol., Publ. No. 66, Symp. Budapest

MD65-6 (continued)

1965. pp 190-200. The mine drainage demonstration program near Elkins, West Virginia is described. OR 65-68

MD65-7 RESEARCH AND DEMONSTRATION PROJECTS IN THE ABATEMENT OF ACID MINE DRAINAGE

Buscavage, J. J. (Pa. Dept. Health), Eng. Ext. Ser. No. 118, Purdue Univ., Proc. 20th Ind. Waste Conf., 1965. pp 664-672. This article reviews the history of the mine drainage problem and summarizes work done on the major projects sponsored by the Mine Drainage Section of the Pennsylvania Dept. of Health, and by the Dept. of Mines, Coal Research Board. OR 65-182

MD65-8 WATER POLLUTION STUDIES IN ACID STRIP-MINE LAKES: CHANGES IN WATER QUALITY AND COMMUNITY STRUCTURE ASSOCIATED WITH AGING

Campbell, R. S., Lind, O. T., Harp, G. L., Geiling, W. T., and Letter, J. E., Jr., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 188-198. Studies of five acid surface mine lakes indicate an orderly series of predictable changes associated with aging. The three distinct and recognizable stages are characterized by marked physical, chemical, and ecological changes. Comparative data are presented. OR 65-53

MD65-9 THE OXIDATION OF COAL MINE PYRITE

Clark, C. S., Ph.D. Thesis, the Johns Hopkins Univ., 1965. 90 pp. The electrochemical nature of pyrite and marcasite decomposition is explored. The roles of bacteria, dissolved oxygen content, temperature, and moisture in controlling the rate of pyrite oxidation are evaluated. A series of experiments were conducted at varying partial pressures of oxygen in the atmosphere over the sample. The theory of pyrite oxidation and factors controlling the rate of acid formation have been studied in detail. OR65-17

MD65-10 SOME FACTORS INVOLVED IN THE OXIDATION OF COAL MINE PYRITE AND WATER QUALITY TRENDS IN THE MONONGAHELA RIVER BASIN

Clark, C. S., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 35-50. Such factors in the oxidation of pyrite as the electrochemical vs. the simple chemical dissociation, and oxidation agents are reviewed briefly. Greater emphasis is given to a review and interpretation of water quality data in the Monongahela River basin. OR 65-39

MD65-11 COOL, CLEAR WATER

Consol News 4 (1), 4-5 (1965). The Elkhorn Public Service Company in southern West Virginia supplies water almost entirely from abandoned coal mines to its customers in an area including Bluefield and Welch. The water issuing from the mines is chlorinated but requires no other treatment to meet the Public Health Department of West Virginia tests for purity and palatability. OR 65-143

MD65-12 RUNOFF CONTRIBUTIONS TO STREAMS FROM CAST OVERBURDEN OF SURFACE MINING OPERATIONS FOR COAL, PIKE COUNTY, INDIANA

Corbett, D. M., Water Resour. Res. Cent., Indiana Univ., Rept. Invest. No. 1, 1965. 67 pp.+ This study established that the low-flow contribution from cast overburden areas of surface mining for coal is significant and also that undesireable effects on the water quality are caused by the cast overburden. Both flow data and quality data are presented for a 270 square mile area containing 26.1 square mile of cast overburden. OR 65-79

MD65-13 EFFECTS OF COAL MINING ON GROUND WATER

Emrich, G. H. (Pa. Dept. Health), SME Fall Meet., Rocky Mountain Miner. Conf., Phoenix, Arix., 1965. Preprint 65-F-311. 11 pp. The geology and hydrology of Western Pennsylvania coal mining areas are discussed to support the view that "if water entering the mine could be contained and the local water table raised, there would be a lessening of the amount of acid draining from the mine." OR 65-180

MD65-14 OPERATION YELLOWBOY

Girard, L., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 102-110. Four process steps - neutralization, aeration, clarification-thickening, and dewatering - have been built into a mobile pilot plant which can be operated at various mine sites. Engineering and economic data are being obtained by Operation Yellowboy at sites representative of different coal mining operations in Pennsylvania. OR 65-45

MD65-15 STATEMENT

Glenn, R. A., Before Pa. House Representatives, Comm. Fisheries, Apr. 15, 1965. 6 pp. The acid mine drainage problem is defined and the types of research needed are described. OR 65-164

MD65-16 COMPOSITION OF GROUND WATER ASSOCIATED WITH COAL IN ILLINOIS AND INDIANA

Gluskoter, H. J., Econ. Geol. 60, 614-620 (1965). Data were collected on uncontaminated ground water samples in underground coal mines in Illinois and Indiana. The mineral constituents in the ground water samples were predominantly alkalies and chloride. All of the ground water samples had a pH of 7.0 or higher. This suggests that removal of these waters soon after they enter the mine might alleviate some problems of acid mine waters. OR 65-9

MD65-17 COAL MINING

Hall, E. P., in "Industrial Wastewater Control," C. F. Gurnham, Ed., New York: Academic Press, 1965. pp 169-181. The water pollution problems of coal mining are discussed. The character of waste discharges and some of the possible corrective measures are reviewed. OR 65-1

MD65-18 A LONG-RANGE LOOK AT WATER POLLUTION FROM COAL MINE DRAINAGE

Hall, E. P., Presented, AIME Fall Meet., Phoenix, Arix., Oct. 1965. 10 pp. This review of the mine drainage problem includes the early history of mine drainage pollution and an assessment of current conditions and future work. OR 65-82

MD65-19 THE SHEBAN PROJECT

Hall, E. P., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 145-160. The Sheban Project which is being conducted in Mahoning County, Ohio was undertaken to study control of water pollution by impoundment of the water in an unreclaimed surface mine operation. Data presented indicate a substantial improvement in Lake Sheban compared to pre-impoundment conditions. Some of the impounded water drained through the spoil and data on the quality of this spoil drainage have shown that water flowing through a spoil bank will leach out oxidized materials and achieve a reasonable improvement in water quality. OR 65-49

MD65-20 WATER AND COAL

Hendricks, E. L., Presented, National Coal Assoc. Conv., June 14, 1965. 8 pp. The author advocates a coordinated geographic, topographic, geologic and hydrologic inventory of surface and underground mine areas before extensive action programs to eliminate mine drainage problems are undertaken. OR 65-23

MD65-21 WESTERN MARYLAND MINE DRAINAGE SURVEY 1962-1965

Hopkins, T. C., Jr., Md. Dept. Water Resour., Water Qual. Div., 1965. Vol. I, Savage River Watershed, Deep Creek Lake Watershed, Youghiogheny River Watershed, Casselman River Watershed, Willis Creek Watershed; Vol. II, Georges Creek Watershed; Vol. III, North Branch Potomac River Watershed. The locations of deep mines and surface mines in Garrett and Allegany Counties in Maryland have been plotted on U.S. Geological Survey maps. Mines were designated as active or inactive. Surface mines were recorded as backfilled to contour, backfilled to law, or not backfilled. Individual mine records and summaries for the seven watersheds are presented.
OR 65-124

MD65-22 MINUS 48 MESH REFUSE DISPOSAL AT U.S. STEEL'S GARY CENTRAL COAL PREPARATION PLANT

Hummer, E. D., Mining Eng. 17 (3), 63-66 (1965). The refuse pumping system, dam design, and impoundment practice used by United States Steel Corp.'s Gary, West Virginia preparation plant for disposal of minus 48 mesh refuse are discussed.
OR 65-109

MD65-23 ISLAND CREEK'S VENTILATION AND DRAINAGE PRACTICES: MINE DRAINAGE AND PUMPING

Coal Age 70 (10), 128-129 (1965). The water-handling practices of Island Creek Coal Company include preventing the inflow of water to underground workings; removing as quickly as possible that which does flow in, and promoting gravity-flow to sumps underground to minimize power requirements. Effluents are monitored and in some instances, suitable for use as washery water. OR 65-154

MD65-24 FOREST RESTORATION OF STRIP-MINED LAND: A RESEARCH CHALLENGE

Johnson, E. A., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 199-206. The U.S. Forest Service, Central States Forest Experiment Station study includes: development of methods for the rapid stabilization of spoil banks through revegetation; study of the chemical reactions occurring in spoil banks; determination of hydrologic processes influencing the quantity and quality of water from mined areas; evaluation of earth movement and placement techniques which offer minimal damage from mining operations; and development of better guides for construction of coal haul roads. OR 65-54

MD65-25 ACID MINE DRAINAGE: MINE SEALING - A PROGRESS REPORT

Krickovic, S., U.S. Bur. Mines, Pittsburgh Mining Res. Cent., Feb. 1964. 3 pp. The project to evaluate air sealing as a means of reducing pollution of surface streams by acid mine water from abandoned above-drainage mines is being carried out at Decker No. 3 Mine, Pa. Some sampling results are presented. OR 65-13

MD65-26 U.S. BUREAU OF MINES ACID MINE DRAINAGE CONTROL PROGRAM AND JOINT INTERIOR-HEW DEPARTMENTS ACID MINE DRAINAGE CONTROL PROGRAM

Krickovic, S., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 111-126. The program of acid mine drainage research at the Bureau of Mines consists of mine sealing, laboratory studies of the physical, chemical, and biological reactions, a demonstration project (Joint Interior - HEW Program), and drainage control. The progress being made in each of these areas is discussed. OR 65-46

MD65-27 CONTRIBUTIONS OF WATER RESOURCE INVESTMENTS TO DEPRESSED ECONOMIES

Lee, J. C. H., Jr., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 219-227. The effects of changes in water resources on depressed areas will be studied as a part of the Appalachian Water Research Survey. Some of the implications of this survey and its relation to the overall Appalachian Program are discussed. OR 65-57

MD65-28 FEASIBILITY STUDY OF APPLICATION OF FLASH DISTILLATION PROCESS TO TREATMENT OF ACID MINE DRAINAGE WATER

Lemezis, S., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 99-101. Corrosion and scaling are two of the major problems anticipated in the flash distillation treatment of acid mine drainage. Although composition of mine drainage waters varies widely, acid and calcium sulfate are generally present. Disposal of separated contaminants is a matter of major concern. Work done so far indicates possible technical feasibility, practical details have not yet been determined. OR 65-44

MD65-29 CONTROL OF MINE DRAINAGE POLLUTION BY REMOVAL OF IMPURITIES FROM DRAINAGE STREAMS

Lovell, H. L., Falconer, R. A., Lachman, R. I., and Reese, R. D., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 92-98. The treatment of acid mine drainage with bituminous coal to reduce the acidity and iron content has been demonstrated. The parameters which affect the response of water to this treatment are outlined. Another phase of the work being conducted is an investigation of the effect of intermixing of streams with different characteristics and the potential of naturally occurring neutralization. OR 65-43

MD65-30 THE IRON-OXIDIZING BACTERIA - CULTURE AND IRON-OXIDATION

Lundgren, D. G. and Schnaitman, C. A., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 14-22. The cultural characteristics of iron-oxidizing bacteria are discussed. An assay system which fulfills the requirements for kinetic studies was devised. Some results of this study are presented graphically. OR 65-37

MD65-31 ACID MINE WATER MOBILE TREATMENT PLANT

Maneval, D. R. and Charmbury, H. B., Mining Congr. J. 51 (3), 69-71 (1965). A truck-mounted plant for treating acid mine waters, designed to use the lime neutralization-aeration-sedimentation-dewatering process, will be tested in five sections of Pennsylvania. Engineering data will be evaluated technically and economically for scale-up to commercial size plants. OR 65-2

MD65-32 A MOBILE DEMONSTRATION PLANT TO COMBAT ACID MINE DRAINAGE

Maneval, D. R., and Charmbury, H. B., Water Sewage Works 112 (7), 268-270 (1965). The objectives of this research program are to perform unit operations such as pumping, mixing, reaction, clarification-thickening, and dewatering in a mobile pilot plant using lime neutralization, aeration, sedimentation, and dewatering. OR 65-151

MD65-33 MOBILE PILOT PLANT TO TREAT ACID MINE DRAINAGE

Maneval, D. R. and Charmbury, H. B., Ind. Water Eng., (March 1965). pp 24-25. This is a preliminary report on studies sponsored by the Commonwealth of Pennsylvania's Coal Research Board to find technically feasible and economically sound solutions to the problems of acid mine drainage. A mobile acid mine drainage treatment plant is described. OR 65-6

MD65-34 ACID MINE DRAINAGE IN THE APPALACHIAN REGION

Musser, J. J., in "Water Resources of the Appalachian Region: Pennsylvania to Alabama," U.S. Geol. Surv., Hydrol. Invest. Atlas HA-198, 1965. Sheet 9. The acid streams are identified and discussed. The amount of acidity as H_2SO_4 discharged annually into a number of streams is tabulated. OR 65-138

MD65-35 REMOVAL OF IRON FROM GROUND WATERS

O'Connor, J. T., Engelbrecht, R. S., and Ghosh, M. M., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 83-91. The problem of removal of iron from ground waters has been studied at the University of Illinois. This study included a survey of the effectiveness and problems of thirty-one iron removal plants. Precipitation rate studies, the effect of organics on precipitation, and analytical procedures for determination of iron were investigated. A pilot plant unit which employs aeration, detention, and filtration units designed in a conventional manner has been set up and some studies are underway. OR 65-42

MD65-36 ORSANCO - SEVENTEENTH ANNUAL REPORT 1965

Ohio River Valley Water Sanitation Commission, Cincinnati, Ohio, 1965. 28 pp. Of particular interest in this Annual Report is the section entitled "River Quality Conditions," describing the monitoring system used on the Ohio River and its tributaries. Maximum, minimum, and average values of nine quality characteristics are contrasted with similar data collected ten years earlier. OR 65-89

MD65-37 A STUDY OF THE REACTIONS BETWEEN COAL AND COAL MINE DRAINAGE

Reese, R. D. and Lovell, H. L., Pa. State Univ., Miner. Ind. Expt. Sta., SR-54, Rept. to Pa. Coal Res. Bd., (1965). 179 pp. The potential use of finely divided coal to remove contaminating acid and iron from coal mine drainage was investigated. Preliminary studies established that coal will react with coal mine drainage to increase pH, decrease acidity, and remove iron. Although it was anticipated that some response would occur between the organic phases of coal and coal mine drainage, this investigation was limited to a study of the reactions between the inorganic phases of the coal and their response to mine water. An attempt was made to determine the mechanism of the phenomena observed. OR 65-179

MD65-38 PLANNING SURFACE MINE RECLAMATION BEFORE MINING

Reilly, J. D., Mining Congr. J. 51 (11), 93-96 (1965). At the surface mining operation of Consolidation Coal Company's Hanna Division, water is controlled by grading, planting, and construction of ponds. OR 65-177

MD65-39 METHODS OF ANALYZING UNDERGROUND FLOW SYSTEMS

Remson, I., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa. 1965. pp 127-135. The application of specialized mathematics and digital computers to the study of underground flow systems is explored. OR 65-47

MD65-40 REPORT ON POLLUTION OF SLIPPERY ROCK CREEK

Pa. Dept. of Health, Div. Sanit. Eng., Publ. No. 8 (1965). 72 pp.+ This survey lists mining operations and the effects of mine drainage on a number of small tributaries to the Creek. OR 65-176

MD65-41 LIMNOLOGY OF ACID MINE WATER IMPOUNDMENTS

Riley, C. V., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 175-187. Determination of the physical and chemical conditions of the impounded waters in relation to specific conditions of the spoil material and to differences between ponds due to age was studied. The extremes of tolerance of fish and other aquatic organisms in the selected impoundments were investigated. Rate studies on physical, chemical, and ecological changes within the selected environment were made. OR 65-52

MD65-42 STUDY OF BACTERIOPHAGES IN CONTROLLING ACID MINE WATER

Shearer, R. E. and Everson, W. A., Symp. Acid Mine Drainage Res. Preprints,

MD65-42 (continued)

Pittsburgh, Pa., 1965. pp 23-34. Phages form a group of bacteria-specific viruses of diverse character which are highly adaptable and specialized. The concept that bacteriophages that would destroy the acid-producing bacteria and proliferate in the process rather than be consumed was developed at MSAR. Some possible evidence supporting this concept has been collected. OR 65-38

MD65-43 STUDIES ON THE REMOVAL OF IRON FROM ACID MINE DRAINAGE

Simpson, D. G. and Rozelle, R. B., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 64-82. Methods for removal of iron from solution which have been reviewed include: precipitation, electrolysis of iron (II) solutions, aeration-filtration, ultrasonic methods, ozone treatment, and irradiation and photo-oxidation. The results of experimental work on ozone oxidation are presented. OR 65-41

MD65-44 PATTERNS OF DISSOLVED OXYGEN IN A THERMALLY LOADED REACH OF THE SUSQUEHANNA RIVER, PENNSYLVANIA

Slack, K. V. and Clarke, F. E., U.S. Geol. Surv. Res. 1965, Prof. Paper 525-C, pp C193-C195. Dissolved oxygen conditions in the West Branch of the Susquehanna River were investigated above and below a steam-electric power plant. Relatively high concentrations of oxygen in the river above the power plant are attributed to the high acidity due to mine drainage which results in a slow rate of organic decomposition. Dissolved oxygen was less below the power plant as a result of decreased solubility of the gas at higher water temperatures. OR 65-115

MD65-45 SOLUTION TO MINE ACID DRAINAGE PROBLEMS PROPOSED BY J & L

Iron Steel Eng. 42 (12), 152 (1965). This news item describes the Jones & Laughlin Steel Corp. mine drainage treatment which includes neutralization, aeration, and sludge disposal. OR 65-59

MD65-46 SOLVING THE PROBLEM OF ACID MINE DRAINAGE

Coal Age 70 (7), 72-77 (1965). The findings and viewpoints of the participants in the First Symposium on Acid Mine Drainage are the basis for this article. The mechanics and prevention of formation of acid in mining, the responsibility and activity of the coal industry, and the treatment of acid are the subjects covered. OR 65-20

MD65-47 THE FEASIBILITY OF SUBSURFACE DISPOSAL OF ACID MINE WATER

Stefanko, R. and Vonder Linden K., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa. 1965. pp 136-144. Subsurface disposal of acid mine water appears to be feasible. Establishment of a pilot injection well in southwestern Pennsylvania is proposed for study of the parameters affecting successful operation of this type of system. OR 65-48

MD65-48 SUBSURFACE DISPOSAL OF ACID MINE WATER BY INJECTION WELLS

Stefanko, R., Vonder Linden, K., and Tilton, J. G., the Pa. State Univ., Miner. Ind. Expt. Sta., SR-52 Rept. to Pa. Coal Res. Bd. (1965). 70 pp. Technical and economic factors of subsurface waste disposal are discussed in relation to acid mine water. The subsurface geology of western Pennsylvania is described and illustrated. OR 65-90

MD65-49 INFLUENCE OF WEATHERING ON STRIP MINE DRAINAGE

Struthers, P. H., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 161-174. The formation of new soil on surface mine spoil banks requires a stable

MD65-49 (continued)

surface since soil cannot form in areas where the surface is constantly changing. Climate and atmosphere alter freshly exposed materials towards a new equilibrium in the process of weathering. At the same time plants and microorganisms introduce biological changes. The possibility of using these environmental changes to promote more rapid and better modification of surface mine spoils is being studied. OR 65-50

MD65-50 RAPID STRIPMINE RECLAMATION

Struthers, P. H. and Vimmerstedt, J. P., Ohio Rept. 50 (6), 84-85, 87, (1965). Improvement of spoil requires the leaching of salts and thus contributes to the drainage problem unless supplementary measures are taken to treat any acid runoff. Among the treatments investigated is the use of pulverized limestone as a neutralizing agent. OR 65-73

MD65-51 OXYGENATION OF FERROUS IRON - PROPERTIES OF AQUEOUS IRON AS RELATED TO MINE DRAINAGE POLLUTION

Stumm, W., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 51-63. A study of the properties of aqueous iron was undertaken in connection with research on corrosion and coagulation. Some of the results of the investigations appear pertinent to a study of the chemical behaviour of iron in acid mine drainage. These studies were done on simple synthetic systems and demonstrate the complex properties of aqueous iron. OR 65-40

MD65-52 SUMMARY REPORT OF PHASE 1 OF THE FEASIBILITY STUDY OF APPLICATION OF FLASH DISTILLATION PROCESS FOR TREATMENT OF ACID MINE DRAINAGE WATER

Westinghouse Elec. Corp., Lester, Pa., 1965. (34 pp.) This report indicates that the flash distillation method can successfully purify acid mine drainage. Materials of construction of equipment, disposal of plant waste products, and economics of the process are discussed. A modification of the continuing program is suggested. OR 65-140

MD65-53 ACID MINE DRAINAGE: PHYSICAL, CHEMICAL, AND BIOLOGICAL REACTION - A PROGRESS REPORT

Tarpley, E. C., U.S. Bur. Mines, Pittsburgh Mining Res. Cent., Feb. 1965. 4 pp. Effluent from the Decker No. 3 Mine was neutralized by sodium carbonate and by hydrated lime. Sludges from each neutralization are described. OR 65-14

MD65-54 MECHANISM OF PYRITE OXIDATION

Walker, J. G. and Randles, C. I., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 10-13. The steps in the change from the sulfur in pyrite to sulfate are considered. The presence of thiosulfate and sulfite as intermediate can be demonstrated. Iron and hydrogen peroxide appear to play an important role in keeping the chain of reactions going. Iron bacteria catalyze the initial removal of electrons from the iron of the pyrite surface thus triggering the subsequent reactions. OR 65-36

MD65-55 GEOCHEMICAL AND HYDROLOGIC CONSIDERATIONS IN ACID MINE DRAINAGE

Whetstone, G. W., Symp. Acid Mine Drainage Res. Preprints, Pittsburgh, Pa., 1965. pp 207-214. Environmental, resource, and economic studies are needed for establishment of sound acid mine drainage control programs. No single procedure will be suitable for all mining areas but combinations of many approaches must be considered. OR 65-55

MD65-56 PROCESS FOR THE BACTERIOLOGICAL OXIDATION OF FERROUS SALTS IN ACIDIC SOLUTION

Glover, H. G., Hunt, J. W., and Kenyon, W. G. [to Coal Industry (Patents) Ltd.] U.S. Pat. 3,218,252 (Nov. 16, 1965). 4 pp. An activated sludge process for the bacteriological oxidation of ferrous salts in acidic medium is claimed. The iron oxidizing bacteria used are believed to be autotrophic ferrobacillus ferrooxidans. An additional process is described for neutralizing the solution by passing it through a reactor containing limestone grit which is continuously subjected to the action of a mechanical attrition device to prevent coating of the limestone. OR 65-70

1966

MD66-1 ACID WATER TREATMENT EQUIPMENT FOR MINES - MILLS - PROCESSING: THE MIXMETER FEEDS CHEMICALS IN SLURRY FORM

Shirley Machine Co., Pittsburgh, Pa., 1966. This brochure describes the Mixmeter which can be adapted to treatment of water by providing regulated feed of hydrated lime to a stream, pond, or volume of water. A typical plant for neutralization of mine acid is described. OR 66-54

MD66-2 AUTOMATIC LIMER PREVENTS POLLUTION

Coal Age 71 (2), 120-121 (1966). A lime feeding device, driven by an overshot water wheel, treats flows ranging from 1/2 to 100 gpm. The pH is raised from 2.6 to 7.5 by feeding 0.13 oz. of lime per 100 gal. of water. Two of the devices have been satisfactorily treating acid mine water at the Aloe Coal Company in Imperial, Pennsylvania, for a year. OR 66-5

MD66-3 REPORT ON ACID MINE-DRAINAGE CONTROL FOR STATE RECLAMATION LANDS, PERRY COUNTY, OHIO

Baker, A. R. and Koehrsen, L. G., Stanley Eng. Co., Rept. to Ohio Dept. Natural Resour. (1966). 99 pp. The survey of the land included the preparation of topographical maps; an aerial survey; stream gaging program; stream water sampling and analysis for acidity, pH, and total iron; lake water quality studies; field work to identify sources of acid pollution; and the determination of response of control areas to a grass seeding program. The program for reduction of acid drainage has been based on the principles of establishing ground cover and reducing erosion, of grading to provide drainage for closed basins and to eliminate shallow pools of acid water, and of burying all exposed coal refuse piles. A plan for chemical neutralization of runoff from two basins is presented. Cost estimates of the various phases of the program are given. OR 66-164

MD66-4 MINE DRAINAGE TREATMENT PROCESSES - FACT AND FICTION

Barthauer, G. L., Coal Age 71 (6), 79-82 (1966). Also 1966 Proc. W. Va. Coal Mining Inst. (1967). pp 1-13. Processes for the treatment of mine drainage discharges are divided into four major categories: "alkali neutralization," "direct iron removal," "demineralization," and "miscellaneous." The first two are discussed in some detail. Demineralization is dismissed as economically not feasible. "Miscellaneous" processes include deep well disposal and treatment with bacteria. OR 66-22

MD66-5 STREAM QUALITY IN APPALACHIA AS RELATED TO COAL-MINE DRAINAGE, 1965

Biesecker, J. E. and George, J. R., U.S. Geol. Surv., Circ. 526, 1966. 27 pp.+ This report summarizes the results of the first major regional stream quality reconnaissance made at 318 locations. The basic water quality characteristics of streams in the area and the effect of mine drainage on the quality are discussed and tabulated. The severity of the mine drainage damage is substantially greater in the more heavily mined northern third of the Appalachian region. Use limitations of water quality parameters typical of coal mine drainage are presented. OR 66-18

MD66-6 COAL MINE EFFLUENTS

Braley, S. A., Symp. Fossil Fuels Environ. Pollut., ACS Div. Fuel Chem., Pittsburgh, 1966. 11 pp. The formation of mine effluents is discussed. Mine sealing and neutralization as means of combating pollution are described briefly. OR 66-1

MD66-7 WATER QUALITY ALTERATION THROUGH ACID AND HEAT POLLUTION IN A 1500 ACRE RESERVOIR

Campbell, R. S. (1), Whitley, J. R. (2), and Brezina, E. R. (1), [(1) Univ. Mo. and (2) Mo. Dept. Conservation], Univ. Mo., Water Resour. Res. Cent. Proj. Rept. No. 1 to U.S. Office Water Resour. Res. (1966). 38 pp. Montrose Lake, constructed by Kansas City Power and Light Company as a source of cooling water, received thermal pollution from steam generation of electricity, alkaline water from fly ash, and acid strip mine drainage. The purpose of the study was to determine the effects of these pollutants on water quality, the biota and the community metabolism of the lake. At fourteen field sampling stations, turbidity, hydrogen ion concentration, dissolved oxygen concentration, bicarbonate alkalinity, and specific conductance, and temperature readings were taken. Acid drainage was found in Deepwater Creek which feeds the lake as well as in the lake itself. Confirmation of the measurable effects of acid drainage on water quality of the lake needs further study. Heat and high turbidity of the water were found to be the significant influences on the environment. A preliminary sampling of biota suggested that the fauna is not rich. OR 66-163

MD66-8 OXIDATION OF COAL MINE PYRITE

Clark, C. S., J. Sanit. Eng. Div., Amer. Soc. Civil Eng. 92 (SA 2), 127-145 (1966). The physical, chemical, and biological factors involved in the oxidation of coal mine pyrite were studied in an attempt to control acid formation. Dissolved oxygen is shown to be a major contributor to the oxidation reaction. Below pH 4.0 bacterial action is significant, however the presence of calcite in the pyrite may prevent oxidation by changing the pH of the environment to a level unfavorable to bacterial action. OR 66-36

MD66-9 CONTROL OF MINE ACID WASTES

Conrad, J. W., Proc. Ill. Mining Inst. Ann. Meet., Springfield, Ill. 1966. pp 104-108. The mine drainage problem and the use of lime neutralization are discussed. Diagrams show typical mine acid treatment plants with automatic pH control and lime charging equipment. The sludge product is used as a neutralizer for culm and gob piles. In an agricultural test using the sludge to treat a corn field, the treated corn grew faster, was much taller, and produced more corn than the control plot. OR 66-172

MD66-10 THE OCCURRENCE OF FUNGI IN ACID MINE-DRAINAGE

Cooke, W. B. (Robert A. Taft Sanit. Eng. Cent.), Eng. Ext. Ser. No. 121, Purdue Univ., Proc. 21st Ind. Waste Conf., May 3-5, 1966. pp 258-274. Many fungi found in other flowing streams were found in acid and sewage polluted waters and in the mud of their banks and bottoms. Apparently these species can adapt to an environment characterized by low pH and high iron concentration but are not the cause of the changes leading to mine drainage pollution. It is suggested that the fungi may be involved in the development of floccules of organically stabilized colloidal iron noticeable as a slime. The method of sampling, the pH and chemical data of samples, and the counts of the cultured organisms are given in detail. OR 66-165

MD66-11 SOME ASPECTS OF ACID MINE WATER ANALYSIS

Corriveau, M. P., Mining Congr. J. 52 (7), 52-53 (1966). Mine water sampling and analysis are discussed. OR 66-134

MD66-12 PROGRESS IN POLLUTION CONTROL IN THE LOTHIANS AREA, SCOTLAND

Covill, R. W., J. Water Pollut. Contr. Fed. 38 (10), 1634-1644 (1966). Among the problems of water control in the Lothians area of Scotland are those associated with collieries and abandoned mines. Drainage from a stocking yard and overflow from an abandoned mine were treated with lime, followed by aeration and sedimentation. Although these problems were solved, the Lothians Board suggests the need for more research in the field of acid mine drainage control. OR 66-106

MD66-13 ACID MINE DRAINAGE CONTROL: THE KEY TO RECREATIONAL DEVELOPMENT IN SOUTHEASTERN OHIO

Dambach, C. A., Proc. Second Ann. Symp. Water Resour. Res., "Water Quality and Recreation in Ohio," Ohio State Univ., Columbus, Ohio, June 15-16, 1966. pp 165-186. State studies are reviewed and the mine drainage problem in the area is discussed. Also included is a tabulation of streams in southeastern Ohio having a potential for recreational development with information on the condition of the stream, its total length, and the length affected by pollution. OR 66-108

MD66-14 HOW STRIP MINING IMPROVES MID-WEST WATER SUPPLIES

Deane, J. A., Coal Age 71 (5), 66-68 (1966). Effects of surface mining on water supplies include construction of lakes, higher infiltration on ungraded spoil, and control of runoff by revegetation. OR 66-47

MD66-15 THE DEEP-MINING GUIDEBOOK: MINE-DRAINAGE METHODS AND WATER-HANDLING EQUIPMENT

Coal Age 71 (8), 214-217 (1966). Procedures for handling water in deep mines are discussed. OR 66-127

MD66-16 THE ROLE OF MICROORGANISMS IN FORMATION AND ABATEMENT OF ACID MINE DRAINAGE

Dugan, P. R., Proc. Second Ann. Symp. Water Resour. Res., "Water Quality and Recreation in Ohio," Ohio State Univ., Columbus, Ohio, June 15-16, 1966. pp 209-226. Bacterial influence on acid mine drainage production and subsequent action of other bacteria which reduce sulfate to sulfide using cellulosic materials as nutrients are discussed. OR 66-112

MD66-17 MINE DRAINAGE, PART I: ABATEMENT, DISPOSAL, TREATMENT

Dutcher, R. R., Jones, E. B., Lovell, H. L., Parizek, R., and Stefanko, R., Mineral Ind., Pa. State Univ. 36 (3), 1-7 (1966). This article is the first in a two-part series concerning projects related to mine drainage problems being carried out by the College of Earth and Mineral Sciences. An abatement program is underway to prevent formation of acid in active mines. Demineralization, neutralization, particulate matter control, and geological-geochemical-biochemical methods are being studied for treatment of mine drainage. Subsurface disposal of acid mine water and watershed management are also being considered. (Part II--MD67-24) OR 66-53

MD66-18 DESIGN AND ECONOMICS OF AN ACID MINE DRAINAGE TREATMENT PLANT - "OPERATION YELLOWBOY"

Girard, L., III and Kaplan, R. A., Symp. Fossil Fuels Environ. Pollut., ACS Div. Fuel Chem. Preprints 10 (1), 107-116 (1966). "Operation Yellowboy" is based on treatment of mine drainage by the lime-neutralization-aeration-dewatering process. The mobile pilot plant is described and some cost data are presented. OR 66-10

MD66-19 HANDBOOK OF POLLUTION CONTROL COSTS IN MINE DRAINAGE MANAGEMENT

U.S. Dept. Int., Fed. Water Pollut. Contr. Admin., 1966. 54 pp. This handbook was

MD66-19 (continued)

prepared by the Monongahela River Mine Drainage Remedial Project and the Advisory Work Group established by the Federal Enforcement Conference in the Matter of Pollution of the Interstate Waters of the Monongahela River and its Tributaries. Typical remedial programs are categorized as underground, surface, waste disposal, and treatment. Cost data presented are based on information in the literature and on economic evaluations of the processes. OR 66-118

MD66-20 DRUMS ALONG OTTER CREEK

Hayes, J., Outdoor Life (1), 27, 40-43, 116-117 (1966). The revolving drum method of treating acid water has worked on Otter Creek where the acid load is light compared with a mine drainage area. This stream now supports trout and other aquatic life where in 1958 it was fishless. OR 66-35

MD66-21 DON'T LET WATER INTERRUPT PRODUCTION

Jones, D. C., Coal Mining Process. 3 (12), 20-27 (1966). Control of water flow and infiltration in mines is described. OR 66-83

MD66-22 WHY USE $KMnO_4$ ON MINE DRAINAGE?

Jones, D. C., Coal Mining Process. 3 (12), 38-40 (1966). Barnes & Tucker Company treats the discharge from their Lancashire No. 15 Mine with potassium permanganate to reduce the iron content of the approximately neutral drainage. OR 66-84

MD66-23 ACID MINE DRAINAGE POLLUTION CONTROL--APPROACH TO SOLUTION

Krickovic, S., Mining Cong. J. 52 (12), 64-68 (Dec. 1966). Methods of water handling to minimize acid production and escape into streams are considered the most feasible for control while further necessary research is carried on. OR 66-171

MD66-24 MINERAL INDUSTRY WATER REQUIREMENTS AND WASTE WATER IN THE SUSQUEHANNA RIVER BASIN

Lorenz, W. C., U.S. Bur. Mines, Area 1 Miner. Resour. Office, 1966. 116 pp. The quantity of water needed by the mineral industry, the sources of water available, and the problems created by water discharges in the Susquehanna River Basin are described in this report. The mineral-producing industries obtained water from mines, and ground water sources as well as from water companies. The major stream pollutants from the mineral industries are drainages from coal mines, preparation plants, and refuse areas of anthracite and bituminous coal operations. OR 66-61

MD66-25 THE CONTROL OF POLLUTION FROM THE COAL INDUSTRY AND WATER QUALITY MANAGEMENT IN FIVE EUROPEAN COUNTRIES

Lyon, W. A. and Maneval, D. R., Pa. Dept. Health, Div. San. Eng., Publ. No. 13, 1966. 26 pp.+ The principal government bodies responsible for water quality and members of the European steel and coal community in the United Kingdom, Netherlands, West Germany, Belgium, and Luxembourg were visited by the authors. In most of the countries visited, there is extensive research going on in connection with water pollution problems associated with the coal industry. Flow sheets for some of the processes discussed are included. OR 66-28

MD66-26 TECHNICAL DEVELOPMENT OF SYSTEMS FOR CONTROLLING POLLUTION BY ACID MINE WASTE

Maneval, D. R. (Pa. Dept. Mines Miner. Ind.), 27th Ann. Internatl. Water Conf. Eng. Soc. Western Pa., Nov. 8, 1966. 16 pp. This paper outlines the acid mine drainage problem, gives the chemistry of the drainage waters and the treatment details. The second part of the paper gives the development of "Yellowboy" pilot

MD66-26 (continued)

plant and includes the results of the various field tests of this pilot unit, used at six sites in the field testing. Chemical data plus cost information are tabulated. OR 66-170

MD66-27 MINE ACID: A GROWING POLLUTION PROBLEM

Eng. News Record 177 (23), 26-28 (1966). Examples of attacks on mine-drainage pollution being made at the federal and state levels and through industry and universities are presented. A discussion of the problems encountered in mine-drainage pollution is included. OR 66-58

MD66-28 MINE DRAINAGE MANUAL

Pa. Dept. Health, Sanitary Water Bd., Publ. No. 12, 1966. (Including 1968 revisions) This manual is "a guide for the preparation of applications, plans of drainage, and reports on bituminous deep and anthracite mines for consideration by the Sanitary Water Board." The structure of the Board and its functions are outlined and excerpts from the Clean Stream Law are cited. The supporting documents and topographic and engineering data necessary for submitting applications are illustrated. OR 66-19

MD66-29 AIR SEALING AS A MEANS OF ABATING ACID MINE DRAINAGE POLLUTION

Moebs, N. N., Symp. Fossil Fuels Environ. Pollut., ACS Div. Fuel Chem. Preprints 10 (1), 93-100 (1966). A small abandoned mine with a highly acid discharge has been selected as a site for extensive studies of the effectiveness of mine air sealing. The geologic and hydrologic environment of the mine is expected to serve as a basis for comparing the quality of mine discharge before and after sealing. The mine openings are to be closed with masonry blocks and mortar, then coated on the outside with urethane foam to assure an airtight seal. Provision will be made for sampling the mine atmosphere periodically. OR 66-9

MD66-30 KINETICS OF THE SULFIDE-TO-SULFATE REACTION

Morth, A. H. and Smith, E. E., Symp. Fossil Fuels Environ. Pollut., ACS Div. Fuel Chem. Preprints 10 (1), 83-92 (1966). The kinetic study of the sulfide-to-sulfate reaction was undertaken to define quantitatively the role of oxygen and water in the reaction kinetics of a chemical, rather than biological, system. Experimental results tend to define the role of water as a reaction medium rather than as a reactant. It may also have as a basic function provision of a means by which the oxidation products are desorbed from the pyrite surface thus increasing the reactivity by clearing "built up" products. Possible kinetic mechanisms by which oxygen enters the rate-limiting reaction are discussed. OR 66-8

MD66-31 "OPERATION YELLOWBOY" - MINE DRAINAGE PLAN, BETHLEHEM MINES CORPORATION MARIANNA MINE NO. 58, MARIANNA, PENNSYLVANIA

Dorr-Oliver Inc., Rept. to Pa. Coal Res. Bd., Jan. 1966. 48 pp.+ The Yellowboy process is a lime neutralization, aeration, sludge dewatering process for treatment of acid mine drainage. Pilot plant data were obtained with and without flocculents. Mine water treated without flocculent produced an effluent having a neutral pH and containing less than 6.0 ppm iron. The use of flocculents resulted in an effluent having less than 2.0 ppm iron at a neutral pH. Cost data are presented. Scale formation was an observed operating problem. Reduction in concentrations of manganese, alumina, and silica were also noted. OR 66-124

MD66-32 OPERATION YELLOWBOY - MINE DRAINAGE PLAN FOR YOUNG AND SON COAL CORPORATION, PARKERS LANDING, PENNSYLVANIA

Dorr-Oliver Inc., Rept. to Pa. Coal Res. Bd., June 1966. 21 pp.+ The site of this

MD66-32 (continued)

Operation Yellowboy test is a drift mine located on the North Branch of Bear Creek near Eau Claire in Butler County. The pH of the mine drainage during the test period was 2.58, and the iron content was 225 parts per million. Treatment by the lime neutralization, aeration, and dewatering process produced a water with a pH of 7.13 and an iron content of 2.4 parts per million. Cost data presented show an estimated cost of $0.72 per 1000 gallons, or $3.25 per ton of coal. OR 66-33

MD66-33 OPERATION YELLOWBOY. MINE DRAINAGE TREATMENT PLANS AND COST EVALUATION

Dorr-Oliver Inc., Rept. to Pa. Coal Res. Bd., June 1966. (79 pp.+) The plans and cost evaluations of treating mine water at the Bethlehem Mines Corporation's Marianna Mine No. 58, Paul Moore's farm on the Little Scrubgrass Creek, the Young and Son Coal Mine on the North Branch of Bear Creek, the Morea Strip Pit on Mill Creek, the Blue Coal Corporation's Loomis No. 4 Shaft, and the Dodge Mine on the Lackawanna River are reported. OR 66-144

MD66-34 ORSANCO 1966: 18TH YEARBOOK

Ohio River Valley Water Sanitation Comm., Cincinnati, Ohio, 1966. 44 pp. The annual report reviews the water quality of the Ohio River. OR 66-63

MD66-35 PENNSYLVANIA'S TEN YEAR MINE DRAINAGE POLLUTION ABATEMENT PROGRAM

Pa. Dept. Health, Sanit. Water Bd., Progr. Rept., Apr. 1, 1966. (9 pp.) This plan to abate mine drainage is a part of the total pollution abatement program being carried out by the Sanitary Water Board. OR 66-160

MD66-36 REASSESSING AN OLD PROBLEM - ACID MINE DRAINAGE

Porges, R., Van Den Berg, L. A., and Ballinger, D. G., J. Sanit. Eng. Div., Am. Soc. Civil Eng. 92 (1), 69-83 (1966). Methods for the control of acid mine wastes resulting from the mining of anthracite and bituminous coal are discussed. The report submitted to the 87th Congress on the subject is summarized. Some suggestions for suitable methods for the determination of acidity in waters containing acid mine drainage are made. OR 66-41

MD66-37 SOME INTERACTIONS BETWEEN COAL AND WATER WHICH CHANGE WATER QUALITY

Reese, R. D. and Lovell, H. L., Symp. Fossil Fuels Environ. Pollut., ACS Div. Fuel Chem. Preprints 10 (1), 117-122 (1966). Experimental work done on various coal and water samples consisted of agitating 10 grams of a coal fraction with 100 ml of water for 10 minutes at room temperature. After filtration both the residue and the filtrate were examined. Results of interaction of various water samples with coal are tabulated and discussed. OR 66-7

MD66-38 REPORT ON WATER QUALITY CRITERIA AND PLAN FOR IMPLEMENTATION - THE INDIANA WATERS OF THE MAIN STEM OF THE OHIO RIVER AND ITS INDIANA TRIBUTARY BASINS EXCLUDING THE WATERS OF THE WABASH RIVER BASIN

Ind. Stream Pollut. Contr. Bd., Nov. 1966. 24 pp. In the watershed area covered by this report on water quality criteria, two coal mines are cited as among those industries which will be required to have adequate control facilities. OR 66-120

MD66-39 REVERSE OSMOSIS TREATMENT

Rinne, W. W., Presented, Coal Convention, Am. Mining Congr., Pittsburgh, Pa., May 1966. 7 pp.+ Reverse osmosis treatment of acid mine water resulted in a product water of exceptional quality. The problem of disposing of the acidic waste brine remains, however concentrating the objectionable substances into smaller volumes may result in a lower cost of disposal treatment. In water containing significant

MD66-39 (continued)

amounts of ferrous iron precautions should be taken to avoid aeration of the feed to suppress oxidation effects. OR 66-23

MD66-40 pH AS A SELECTING MECHANISM OF THE MICROBIAL FLORA IN WASTEWATER POLLUTED ACID MINE DRAINAGE

Rogers, T. O. and Wilson, H. A., J. Water Pollut. Contr. Fed. 38 (6), 990-995 (1966). This study of sewage in the Monongahela River showed that when the river water was acid the microbial population would be reduced and probably also changed in the types of organisms predominating. OR 66-38

MD66-41 STUDY AND ANALYSIS OF THE APPLICATION OF SALINE WATER CONVERSION PROCESSES TO ACID MINE WATERS

Schroeder, W. C. and Marchello, J. M., Univ. Md., Dept. Chem. Eng., Res. Develop. Progr. Rept. No. 199, to U.S. Dept. Int., Office Saline Water (1966). 65 pp. Nine saline water conversion processes, including distillation, crystallization or freezing, membrane, and ion exchange processes have been examined to determine their applicability to acid mine water pollution. It is concluded that the processes considered would not apply to acid mine waters, except where a municipality needed an additional supply of potable water meeting Public Health standards and could meet the capital and operating costs involved. Economic data are presented for the various processes. OR 66-101

MD66-42 SEWICKLEY CREEK AREA, PENNSYLVANIA

U.S. Dept. Int., Fed. Water Pollut. Contr. Admin., Monongahela River Mine Drainage Remedial Project 1966. 68 pp. The extent of pollution is the drainage basin of this tributary to the Youghiogheny River has been surveyed through a field inventory of mine drainage sources. Also included in the report are the geology and stratigraphy of the area and its history of mining. Active as well as inactive sites are found to be the source of pollution. OR 66-167

MD66-43 INTENSIVE STUDY OF THE WATER AT CRITICAL POINTS ON THE MONONGAHELA, ALLEGHENY AND OHIO RIVERS IN THE PITTSBURGH, PENNSYLVANIA AREA

Shapiro, M. A., Andelman, J. B., and Morgan, P. V., Univ. Pittsburgh, Grad. School Public Health, Neville Island Res. Lab., Rept. to U.S. Dept. Int., Fed. Water Pollut. Contr. Admin. Contract No. PH-86-84-124 (undated). 112 pp.+ The results of the study showed that the following pollutants are added in significant amounts: acidity, hardness, calcium, sulfate, iron, manganese, sodium chloride, phenol, total solids, and BOD. The streams carrying the greatest amount of acid mine wastes--the Kiskiminetas and the Monongahela--also exhibit the highest maximum concentrations of hardness, calcium, magnesium, manganese, sulfate, iron, potassium, ammonia nitrogen, total solids, low alkalinity, and low pH. The bacterial densities in the same streams were the lowest of all sampled. OR 66-150

MD66-44 MINE ACID: ITS EFFECT ON CHAIN CONVEYORS

Shuler, J. H., Coal Age 71 (4), 117-118, 120 (1966). A special chemically deposited nickel plating, which is non-porous, resisted mine acid attack on a conveyor chain. Corrosion of other materials is illustrated. OR 66-46

MD66-45 ENGINEERING ASPECTS OF ACID MINE DRAINAGE

Smith, E. E., Proc. Second Ann. Symp. Water Resour. Res., "Water Quality and Recreation in Ohio," Ohio State Univ., Columbus, Ohio, June 15-16, 1966. pp 187-203. Factors affecting the rate of pyrite oxidation and mine drainage production are discussed. OR 66-111

MD66-46 ACID MINE WATER NEUTRALIZATION

Steinman, H. E., Presented, AMC Meet., Pittsburgh, Pa., May 1966. 11 pp.+ The installation of an acid mine water neutralization plant has proven successful at the Thompson borehole near Beallsville, Pa. The water was diverted to a mixing tank where it was treated with lime slurry, aerated, and then entered a settling lagoon. An abandoned mine with a depleted coal horizon below the river level was used for disposal of the sludge. Sludge disposal is still the most critical of the problems associated with the neutralization plant. A schematic diagram for an automatic neutralization lime treatment plant is included with the report. OR 66-39

MD66-47 A STUDY OF THE INTERACTIONS AND FOAM FRACTIONATION OF SEWAGE EFFLUENT--ACID MINE DRAINAGE MIXTURES

Streeter, R. C. and McLean, D. C. (Dept. Miner. Prep.), Pa. State Univ., Final Rept. to U.S. Dept. Int., Office Water Resour. Res., 1966. 56 pp. Sewage effluent-acid mine drainage mixtures are treated in a continuous process by aeration, fluid-solid separation, and foam fractionation. Partial neutralization of the acid mine drainage occurs. Anions such as phosphate, organic materials resistant to conventional sewage treatment, and appreciable amounts of iron are removed. The addition of acid mine drainage to raw sewage is suggested for further evaluation. OR 66-166

MD66-48 AN ECONOMIC FRAMEWORK FOR EVALUATION OF ACID MINE DRAINAGE

Tybout, R. A., Proc. Second Ann. Symp. Water Resour. Res., "Water Quality and Recreation in Ohio," Ohio State Univ., Columbus, Ohio, June 15-16, 1966. pp 227-249. The difficulties of measuring the many direct and indirect costs of mine drainage pollution and comparing them to costs of abatement are discussed. OR 66-113

MD66-49 STUDY OF STRIP AND SURFACE MINING IN APPALACHIA

Udall, S. L., U.S. Dept. Int., Interim Rept. to Appalachian Regional Comm., (1966). 78 pp. A program for federal participation with state, local government and industry for reclamation of areas adversely affected by strip and surface mining in the Appalachian region is outlined. Some statistical data relating to strip-mining in Appalachia and a comparison of state laws relating to strip-mining in effect on March 1, 1966, are included as appendix. OR 66-59

MD66-50 SUBSURFACE DISPOSAL OF ACID MINE WATER

Vonder Linden, K. and Stefanko, R., Symp. Fossil Fuels Environ. Pollut., ACS Div. Fuel Chem. Preprints 10 (1), 101-106 (1966). Each subsurface disposal well must be viewed as an individual engineering problem. The presence of bacteria, dissolved gases, and iron all pose special problems in the handling of mine water. OR 66-6

MD66-51 EROSION FROM ABANDONED COAL-HAUL ROADS

Weigle, W. K. (U.S. Dept. Agr., Forest Serv., Berea, Ky.), J. Soil Water Conserv. 21 (3) (May-June 1966). A survey was made of eight abandoned roads selected at random in three mountainous Kentucky counties. Because soil losses from the roads were estimated to be between 1.7 and 3.3 acre feet of soil per mile each year, the author urges that vegetative cover be provided for abandoned roads and provisions for maintenance be made for roads which will continue to be used. OR 66-169

1967

MD67-1 ACID MINE DRAINAGE TREATED BY TWO NEW APPROACHES

Chem. Eng. News 45 (29), 24 (1967). This news report describes an automated plant for treating several million gallons per day of acid drainage being designed by Heyl & Patterson, and Bethlehem Steel Corporation's use of acid mine drainage to wash the raw coal produced by its Marianna, Pennsylvania, mine. OR 67-78

MD67-2 APPALACHIA PROGRAM, WATER SUPPLY & WATER QUALITY CONTROL NEEDS, ST. PETERSBURG RESERVOIR, CLARION RIVER, PA., ALLEGHENY RIVER BASIN

Wheeling Field Station, FWPCA, U.S. Dept. Int., Rept. to U.S. Dept. Army, Corps Engineers--Appalachia Study, Pittsburgh, Pa. (1967). 57 pp. The purpose of this investigation was to determine the need for and value of water supply and/or water quality control storage in the proposed St. Petersburg Reservoir to augment low flow in the Allegheny River. The intermittently degraded quality of Allegheny River water is described. Water of the Clarion River was found to be so degraded by acid mine drainage, that its storage for water quality control of the Allegheny was not recommended in St. Petersburg Reservoir unless the acid drainage is controlled. Appendix 1 gives the detailed results of mine drainage source investigation in the Clarion River Basin. Oil and gas wells, as well as mines, were found to be sources of acid pollution. Preliminary abatement costs are estimated. OR 67-184

MD67-3 FEASIBILITY STUDY ON THE APPLICATION OF VARIOUS GROUTING AGENTS, TECHNIQUES AND METHODS TO THE ABATEMENT OF MINE DRAINAGE POLLUTION. PART I. EXPLORATION OF MINE SITES AND FEASIBILITY STUDY ON TECHNIQUES OF MATERIALS APPLICATION

Baker, A. A. (Project Manager), Halliburton Co., Rept. to Fed. Water Pollut. Contr. Admin., U.S. Dept. Int., Monongahela River Mine Drainage Remedial Proj., 1967. 297 pp. Twenty mine sites in the Upper West Fork River subbasin of the Monongahela River watershed were chosen for intensive study of grouting methods to control drainage. The choice was made from 228 sites identified in a preliminary geologic and hydrologic survey. Information on water quality, flow data, and geology of all sites are given in appendices to the report. A variety of materials for grouting, as well as equipment and handling techniques for the process are described and evaluated. Costs are given for proposed remedial measures. OR 67-191

MD67-4 FEASIBILITY STUDY ON THE APPLICATION OF VARIOUS GROUTING AGENTS, TECHNIQUES AND METHODS TO THE ABATEMENT OF MINE DRAINAGE POLLUTION. PART II. SELECTION AND RECOMMENDATION OF TWENTY MINE SITES

Baker, A. A. (Proj. Manager), Halliburton Co., Rept. to U.S. Dept. Int., FWPCA, Monongahela River Mine Drainage Remedial Project, Aug. 23, 1967. 286 pp. Twenty mine sites in the Upper West Fork River Subbasin of the Monongahela River watershed were chosen for intensive study. The description and discussion of each site is accompanied by a data list, representation of geologic section, an aerial photograph, and, where available, a mine map. One of the sites has been used in field testing Expendable Grout Retainers, which are fabric retainers placed in the mine to hold the grout in place until it hardens. The flexibility of the fabric allows the plug to conform to the irregularities of the mine opening. Two tables list analyses of mine discharges and the status of the 228 sites originally inventoried. The comparative acid and iron loads at twenty sites selected are also tabulated. OR 67-193

MD67-5 FEASIBILITY STUDY ON THE APPLICATION OF VARIOUS GROUTING AGENTS, TECHNIQUES AND METHODS TO THE ABATEMENT OF MINE DRAINAGE POLLUTION. PART III. PLANS, SPECIFICATIONS AND SCHEDULES FOR REMEDIAL CONSTRUCTION

Baker, A. A. (Proj. Manager), Halliburton Co., Rept. to U.S. Dept. Interior, FWPCA, Monongahela River Mine Drainage Remedial Project, Nov. 30, 1967. (323 pp.) Three mine sites, one a complex of three mines, were selected for further study from those inventoried and evaluated in Parts I and II of this investigation. The report includes a general description of the three sites as well as the detailed plans, specifications and schedules, and estimation of costs for contracting and constructing pollution abatement remedial measures. OR 67-194

MD67-6 PRACTICAL ASPECTS OF MINE DRAINAGE CONTROL AND TREATMENT

Barthauer, G. L., AIME Ann. Meet., Los Angeles, Calif., Feb. 1967. Preprint No. 67F72. 19 pp. In this state-of-the-art discussion of mine drainage, the chemical

MD67-6 (continued)

basis for treatment of effluent is discussed. Aeration, neutralization, settling treatment, as it applied in specific situations, is outlined. The impact of today's laws on the miner is also considered. OR 67-54

MD67-7 PUMPING ACID MINE WATER FROM THE WEST BRANCH OF THE SUSQUEHANNA RIVER INTO AN ABANDONED MINE TO IMPROVE THE ALKALINITY CONTENT

Birch, J. J., Barnes & Tucker Co., Rept. to Pa. Coal Res. Board, Dec. 11, 1967. 25 pp. Acid water from the river was pumped into an abandoned mine complex of Lancashire Mine No. 12 containing an estimated 0.52 billion gallons of highly alkaline water which flows by gravity from three boreholes to Beaver Run, a clean stream flowing into West Branch Susquehanna River near the village of Pachinville. Sustained pumping of 2,000 gpm of acid water into the abandoned mine complex caused a slight fluctuation of pH, alkalinity, and iron in the discharge to Beaver Run for the first few months and then stabilized. OR 67-127

MD67-8 "BLACK WATER" + COAL PELLETIZING SYSTEM = NEW MARKET IN COAL PELLETS

Coal Age 72 (7), 26-28 (1967). Water clarification, coal fines recovery, and pelletizing plant of Eastern Coal Corp. will produce high quality coal to meet needs of metallurgical and double-screened nut and slack steam markets. A significant fringe benefit is clarification of processing plant waste water. OR 67-168

MD67-9 A REVIEW OF THE LITERATURE OF 1966 ON WASTEWATER AND WATER POLLUTION CONTROL COAL WASTES

Boros, J. A., J. Water Pollut. Contr. Fed. 39 (6), 877-879 (1967). This brief review of the acid mine drainage problem covers mine sealing and flow regulation, measurement of changes noted following the enforcement of control measures, the Yellowboy process, lime neutralization, and the study of the kinetics of the aqueous oxidation of coal mine pyrites with the DO content in the solution kept constant. There are 16 references. OR 67-42

MD67-10 PROBLEMS IN CONTROL OF COAL MINE DRAINAGE

Boyer, J. F., Jr., Pa. Water Pollut. Contr. Assoc. Meet., State College, Pa., Aug. 10, 1967. 20 pp. Some of the variable conditions that affect the quality of discharge from mines are discussed. Two types of treatment systems are also described, one using lime, the other using limestone. OR 67-135

MD67-11 AN EVALUATION OF FACTORS INFLUENCING ACID MINE DRAINAGE PRODUCTION FROM VARIOUS STRATA OF THE ALLEGHENY GROUP AND THE GROUND WATER INTERACTIONS IN SELECTED AREAS OF WESTERN PENNSYLVANIA

Caruccio, F. T. and Parizek, R. R., Pa. State Univ., Dept. Geol. Geophysics, SR-65, Rept. to Pa. Coal Res. Bd. (1967). 213 pp.+ Rock and water samples were collected from an area underlain by Lower and Middle Kittanning and from a second study area underlain by Upper Kittanning and Lower Freeport formations. The former area produced acid mine drainage but the latter did not. A comparison of the compositional variations and of the hydrologic characteristics of the two areas showed that the ranges of total sulfur contents of the two areas were similar and could not account for the different water qualities produced. Leaching tests showed acid generation to be partly dependent on the sulfur content of a sample and to be greatly influenced by the crystallinity of the pyrite, the presence of iron bacteria, and calcium carbonate. OR 67-87

MD67-12 ACID MINE DRAINAGE CAN BE STOPPED

Charmbury, H. B., Coal Mining Process. 4 (1), 33-35 (1967). The program of the Pennsylvania Department of Mines and Mineral Industries to combat acid drainage from coal mines is reviewed. OR 67-122

MD67-13 OPERATION YELLOWBOY - DESIGN AND ECONOMICS OF A LIME NEUTRALIZATION MINE DRAINAGE TREATMENT PLANT

Charmbury, H. B., Maneval, D. R., and Girard, L., III, AIME Ann. Meet., Los Angeles, Calif., Feb. 1967. Preprint No. 67F35. 15 pp. In "Operation Yellowboy," mine water was treated by the lime neutralization, aeration, sedimentation, and dewatering process to produce a product containing less than 7 ppm of iron at a neutral pH and with a small degree of free alkalinity. OR 67-10

MD67-14 CLEAR, ALKALINE RUN-OFF IS J&L'S GOAL IN WATER-TREATMENT PLAN

Coal Age 72 (8), 70-74 (1967). Each of five mine-water discharges at the Vesta-Shannopin coal mines in southwestern Pennsylvania requires complete analysis of the effluent and development of a control plan which considers the variables which may be encountered at individual discharge points. The five discharge points and the treatment being applied are described. OR 67-76

MD67-15 AN OLD PROBLEM - ACID MINE DRAINAGE

Cleary, E. J., Chapter 14 in "The ORSANCO Story: Water Quality Management in the Ohio Valley Under an Interstate Compact," Baltimore; the Johns Hopkins Press, 1967. pp 167-187. Some background on the problem is given and the activities of the Coal Industry Advisory Committee to ORSANCO are discussed. OR 67-50

MD67-16 SOLVING THE PROBLEM OF MINE ACID WATER POLLUTION

Conrad, J. W., Analyzer 8 (1), 16-17 (1967). Equipment developed by the Tasa Coal Company for automatic neutralization of acid mine drainage ranges in size from the "Autolimer," which is the smallest, to the "Mixmeter," which can handle volumes ranging from 10,000 to 90,000 gph. OR 67-26

MD67-17 COMPOSITION OF WATER DISCHARGED FROM BITUMINOUS COAL MINES IN NORTHERN WEST VIRGINIA

Corbett, R. G. and Growitz, D. J. (W. Va. Univ.), Econ. Geol. 62 848-851 (1967). Effluent from four mines producing acid drainage are compared to water from a mine designed for frequent discharge. Analyses for pH, ferrous iron, total iron, aluminum, manganese, sodium, potassium, calcium, magnesium, chloride, sulfate, and silica show markedly lower ferrous, total iron, and aluminum in the neutral drainage from the frequent discharge mine. To aid in characterizing mine drainage, the neutral drainage, pH 7.4, and an acid drainage, pH 3.2 are compared as to amounts of 13 other selected trace elements. OR 67-178

MD67-18 TRACE ELEMENTS IN BITUMINOUS COAL MINE DRAINAGE AND ASSOCIATED SULFATE MINERALS

Corbett, R. G., Nuhfer, E. B., and Phillips, H. W. (W. Va. Univ., Dept. Geol. Geography), Proc. W. Va. Acad. Sci. 39, 311-314 (1967). Trace elements in sulfate minerals at seep sites, in samples from discharge pumps in northern West Virginia, and in precipitates at pump sites were determined by emission spectroscopy. More trace elements were detected in acid, high-iron drainage than in neutral, low-iron drainage. Also, the mobilities of the various elements were evaluated. OR 67-205

MD67-19 ACID MINE DRAINAGE ABATEMENT -- WHERE DO WE STAND?

Core, J. F., Proc. 15th Ann. Pa. Clean Streams Clean Air Conf., 1967. pp 18-22. The mine drainage problem, the implementation of the Clean Streams Act of Pennsylvania, and some treatment methods are discussed. OR 67-43

MD67-20 HYDROLOGY OF CONTOUR STRIP MINES IN THE APPALACHIAN REGION OF THE UNITED STATES

Davis, G. (Forest Serv., U.S. Dept. Agr.), Intern. Union Forest Res. Organizations

MD67-20 (continued)

Proc., 14th Congr., Munich, W. Germany, 1967. pp 420-443. The methods of surface mining and auger mining are described to show how they can cause erosion, landslides, deterioration of water quality, and changes in stream flow and drainage. Water quality change is discussed in detail with emphasis on acidity formed from freshly exposed pyritic material and an increase in dissolved solids. The rocky nature of spoils makes measurements of hydrologic changes difficult. Methods of land reclamation, including grading, burying acid forming spoils, and revegetation, are noted. OR 67-192

MD67-21 MINE WATER RESEARCH: NEUTRALIZATION

Deul, M. and Mihok, E. A., U.S. Bur. Mines, RI 6987 (1967). 24 pp. Treatment of acid mine water using lime, coarse limestone, and limestone followed by lime was studied. Results from tests with nine mine waters covering a wide range of iron and acid concentrations showed that coarse limestone, with abrasive agitation, is potentially useful for treating mine water discharges. For mine waters containing low to moderate concentrations of iron, the treated water had a pH of 7.0 to 8.0 and an iron concentration of less than 7.0 ppm. In the case of high iron mine waters, a supplemental treatment with lime was necessary in order to reduce the reaction time. OR 67-32

MD67-22 WASTE DISPOSAL MADE PROFITABLE

Dillon, K. E., Chem. Eng. 74 (6), 146-148 (1967). The use of mine water by Bethlehem Mines Corporation at the coal preparation plant in Marianna, Pennsylvania is described. The raw coal content of calcium and magnesium carbonate provides more than enough alkalinity to neutralize the acidic mine water. OR 67-172

MD67-23 ROLE OF THIOBACILLUS FERROOXIDANS IN THE OXIDATION OF SULFIDE MINERALS

Duncan, D. W., Landesman, J., and Walden, C. C., Can. J. Microbiol. 13, 397-403 (1967). To demonstrate that washed cell suspensions of *Thiobacillus ferrooxidans* attack both insoluble ferrous iron and sulfide during the oxidation of chalcopyrite and pyrite, selective inhibitors of iron and sulfide oxidation were used. This laboratory study explored the effect of source of the cell on rate of oxidation. OR 67-63

MD67-24 MINE DRAINAGE, PART II: THE HYDROGEOLOGIC SETTING

Dutcher, R. R., Jones, E. B., Lovell, H. L., Parizek, R., and Stefanko, R., Mineral Ind., Pa. State Univ. 36 (4), 1-7 (1967). Suggestions are made concerning how watershed management programs may benefit by utilizing the geology and hydrology of a region. See MD66-17. OR67-53

MD67-25 ELIMINATION OF POLLUTION IN MINE DRAINAGE

Everson, W. A. and Shearer, R. E., MSA Res. Corp., MSAR 67-111, Progr. Rept. No. 6, to Pa. Dept. Mines Miner. Ind., 1967. 30 pp. This is a feasibility study on the isolation, development, and use of bacteriophages to control the activity of iron and sulfur bacteria in production of acid mine drainage. There was a significant reduction in acid from piles of coal with water flowing through them by the addition of neutral mine effluents shown to have inhibitory powers. OR 67-18

MD67-26 THE ANALYSIS OF METALS IN ACID MINE WATERS BY ATOMIC ABSORPTION SPECTROPHOTOMETRY

Feige, W. A., M.S. Thesis, Univ. Cincinnati, 1967. 66 pp. The purpose of the research described in this thesis was to develop procedures for the analysis of metals in acid mine drainage samples by atomic absorption spectroscopy. Optimum conditions for the determination of dissolved iron, manganese, aluminum, and calcium were investigated. OR 67-86

MD67-27 WATER RESOURCES OF THE MONONGAHELA RIVER BASIN, WEST VIRGINIA

Friel, E. A., Wilmoth, B. M., Ward, P. E., and Wark, J. W. (U.S. Geol. Surv.), W. Va. Dept. Natural Resour., Div. Water Resour., 1967. 118 pp. The amounts and sources of available water and the quality of these water resources in the study area are presented. Results of chemical analyses are tabulated for silica, aluminum, iron, manganese, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, nitrate, dissolved solids, calcium carbonate hardness, specific conductance, pH, color, and phosphate. Concentrations of boron, copper, and zinc, as well as dissolved oxygen and temperature, are also listed for selected sampling points. There is an extensive bibliography. OR 67-198

MD67-28 "OPERATION YELLOWBOY"...TREATMENT OF ACID MINE DRAINAGE

Girard, L. and Kaplan, R. A., Coal Age 72 (1), 72-74, 79 (1967). The "Yellowboy" process uses lime neutralization-aeration-dewatering. Data in this article demonstrate the range of mine drainage fluctuation and treatment economics. OR 67-3

MD67-29 THE CONTROL OF ACID MINE DRAINAGE POLLUTION BY BIOCHEMICAL OXIDATION AND LIMESTONE NEUTRALIZATION TREATMENT

Glover, H. G. (Natl. Coal Board, U.K.), Eng. Ext. Ser. No. 129, Proc. 22nd Ind. Waste Conf., Purdue Univ., 1967. pp 823-847. A new process for the purification of acid drainage from coal mining operations is described. Novel features include the biochemical oxidation of ferrous salts in acid solution and the application of mechanical attrition to limestone grit which is used for the chemical neutralization of the oxidized drainage. (From author's Summary) OR 67-204

MD67-30 CORROSION STUDY IN INDIAN COAL MINES

Gupta, A. and Mukherjee, K. P., J. Mines, Metals, Fuels 15 (3), 78-83 (1967). Factors such as temperature, humidity, and characteristics of pit waters have been studied and their respective roles in the field of corrosion have been discussed with reference to studies made by previous workers. The occurrence and disposal of acid mine water poses special problems. The formation of acid by the natural oxidation of sulfur is slow, but the presence of sulfur oxidizing bacteria enhances the rate of formation of sulfuric acid. OR 67-124

MD67-31 A REPORT ON RECOMMENDED WATER QUALITY CRITERIA AND USES RELATIVE TO INTERSTATE WATERS IN THE KANAWHA RIVER

Henry, E. N., W. Va. Dept. Natural Resour., Div. Water Resour., Rept. to W. Va. Water Resour. Bd., 1967. 33 pp.+ Tabulation of results of analyses of water samples taken at a number of points are included. OR 67-5

MD67-32 A REPORT ON RECOMMENDED WATER QUALITY CRITERIA AND USES RELATIVE TO INTERSTATE WATERS WITH PENNSYLVANIA - MARYLAND

Henry, E. N., W. Va. Dept. Natural Resour., Div. Water Resour., Rept. to W. Va. Water Resour. Bd., 1967. 37 pp.+ This report on the Monongahela River Basin in West Virginia includes tabulation of results of analyses of water samples taken at a number of points. OR 67-9

MD67-33 A REPORT ON RECOMMENDED WATER QUALITY CRITERIA AND USES RELATIVE TO INTERSTATE WATERS WITH PENNSYLVANIA - OHIO - KENTUCKY

Henry, E. N., W. Va. Dept. Natural Resour., Div. Water Resour., Rept. to W. Va. Water Resour. Bd., 1967. 41 pp.+ The Ohio River and its minor tributaries, including the Little Kanawha River, are the subject of this report. Analyses of water samples taken at a number of points are tabulated. OR 67-8

MD67-34 A REPORT ON RECOMMENDED WATER QUALITY CRITERIA AND USES RELATIVE TO INTERSTATE WATERS WITH VIRGINIA

Henry, E. N., W. Va. Dept. Natural Resour., Div. Water Resour., Rept. to W. Va. Water Resour. Bd., 1967. 39 pp.+ The New River, the Gauley River and their tributaries are the subject of this report. Tabulation of results of analyses of water samples taken at a number of points are included. OR 67-6

MD67-35 A REPORT ON RECOMMENDED WATER QUALITY CRITERIA AND USES RELATIVE TO INTERSTATE WATERS WITH VIRGINIA AND KENTUCKY

Henry, E. N., W. Va. Dept. Natural Resour., Div. Water Resour., Rept. to W. Va. Water Resour. Bd., 1967. 35 pp.+ Tug Fork, Big Sandy River Basin and the Guyandotte River Basin are covered in this report. Tabulation of results of analyses of water samples taken at a number of points are included. OR 67-7

MD67-36 PHYSICAL AND CHEMICAL WATER QUALITY FROM THE EFFECTS OF MINE DRAINAGE IN WESTERN MARYLAND

Hopkins, T. C., Jr., Md. Dept. Water Resour., Aug. 1967. 19 pp. A previous report "Western Maryland Mine Drainage Survey 1962-1965" listed and evaluated effluents from all mines which could be located in the seven watersheds in Garrett and Western Allegany Counties. Quality of the waters of the rivers and the main feeder streams affected by the mine drainages listed in that survey was assessed by samples taken at 44 designated stations. Values are given for field and laboratory pH, air and water temperatures, flow rate, total and mineral acidity, total iron, aluminum, manganese, sulfate, total alkalinity, and hardness. OR 67-197

MD67-37 ACID MINE DRAINAGE NEUTRALIZED IN MARIANNA'S PREP PLANT

Jones, D. C., Coal Mining Process. 4 (3), 35-39 (1967). The prime method of treating Bethlehem Mines Corporation's Marianna acid mine drainage is to introduce a controlled quantity into the coal preparation system. Research studies have established that the action of coal on coal mine drainage is effective in increasing pH, decreasing acidity, and removing iron. Some plant details and typical water analyses at various points in the process are presented. OR 67-27

MD67-38 J & L INITIATES AMD CONTROL WITH LIME SLURRY PILOT PLANT

Jones, D. C., Coal Mining Process. 4 (7), 32-35 (1967). A full-scale plant for treatment of acid mine drainage, constructed at the Thompson borehole discharge, involves an automatically-controlled Mixmeter unit which feeds a slurry of lime to a mixing tank, aeration, and settling. The product water has a pH of 8.0 or higher and is almost free of iron. Sludge formed in the operation is discharged into the abandoned Vesta No. 6 Mine. OR 67-28

MD67-39 TRACING WATER POLLUTION WITH AN EMISSION SPECTROGRAPH

Kopp, J. F. and Kroner, R. C., J. Water Pollut. Contr. Fed. 39 (10), 1659-1668 (1967). One facet of this study is a detailed analysis of samples from five rivers affected by mine drainage--the Allegheny, Monongahela, Kiskiminetas, Youghiogheny, and Ohio Rivers--compared to six samples of mine drainage analyzed for a number of trace elements. OR 67-126

MD67-40 LACKAWANNA VALLEY MINE DRAINAGE POLLUTION ABATEMENT PROJECT

Gannett Fleming Corddry & Carpenter, Inc., Rept. to Pa. Dept. Health, Div. Sanit. Eng., Publ. No. 19 (1967). 47 pp. This report is a study of the feasibility and economic considerations of dewatering underground mine pools through the Butler Water Tunnel. OR 67-67

MD67-41 FACTORS THAT AFFECT THE FORMATION OF COAL MINE DRAINAGE POLLUTION IN APPALACHIA

Lorenz, W. C. and Stephan, R. W., U.S. Bur. Mines, Area I Mineral Resource Office, Pittsburgh, Pa., 1967. 17 pp. Research on pyrite oxidation is reviewed. There are 53 references. OR 67-16

MD67-42 THE OXIDATION OF PYRITE ASSOCIATED WITH COAL MINES

Lorenz, W. C. and Stephan, R. W., U.S. Bur. Mines, Area I Miner. Resource Office, Pittsburgh, Pa., 1967. 21 pp. A survey of the literature and current research on the oxidation of pyrite, both chemical and bacterial, is presented to indicate progress in this field. (From authors' abstract) OR 67-147

MD67-43 THEY HAVE MINE DRAINAGE PROBLEMS IN EUROPE, TOO

Maneval, D. R., Coal Mining Process. 4 (2), 26-31 (1967). Coal in Western Europe is mined from areas with a saline coal bearing layer, and thus there is a saline water pollution problem. In the United Kingdom, the acid mine drainage problem is somewhat similar to that in the United States. A number of pollution control approaches investigated by the National Coal Board are discussed. OR 67-25

MD67-44 CHEMICAL QUALITY OF SURFACE WATER IN THE ALLEGHENY RIVER BASIN, PENNSYLVANIA AND NEW YORK

McCarren, E. F., U.S. Geol. Surv. Water-Supply Paper 1835 (1967). 74 pp.+ The water quality problems in the basin include wastes from coal mines and oil wells. Chemical quality of a number of tributaries and at several sampling points on the main stream are reported. OR 67-38

MD67-45 MINE DRAINAGE: NEW RESEARCH ON AN OLD PROBLEM

Coal Res., (28), 1-7 (1967). The involvement of Bituminous Coal Research, Inc., since 1944, in field and laboratory studies to find methods to prevent stream pollution from coal mine waters is described. The present research program at BCR covers mine drainage formation, prevention, treatment, and sludge disposal. OR 67-125

MD67-46 ORSANCO 1967: 19TH YEARBOOK

Ohio River Valley Water Sanitation Comm., Cincinnati, Ohio, 1967. 40 pp. Activities of the Commission in its eight member states during the past year are reviewed. OR 67-111

MD67-47 MATERIALS HANDLING AND ENVIRONMENTAL CONTROL RESEARCH

Palowitch, E. R., Mining Congr. J. 53 (4), 42-47 (1967). The research program of the Pittsburgh Mining Research Center, Bureau of Mines, includes studies on water flow into mines, and the effectiveness of air sealing abandoned deep mines above drainage. OR 67-60

MD67-48 PENNSYLVANIA'S TEN YEAR MINE DRAINAGE POLLUTION ABATEMENT PROGRAM FOR ABANDONED MINES

Pa. Dept. Health, Sanit. Water Bd., Progr. Rept., 2nd ed., March 1, 1967. 13 pp. This progress report outlines the objectives and budgetary considerations of the program, and includes a list of research and development projects supported by the Pennsylvania Department of Mines and Mineral Industries, the Appalachian Regional Commission, Army Corps of Engineers, the Federal Water Pollution Control Administration, the United States Bureau of Mines, the United States Forest Service, the coal industry, and the Pennsylvania Department of Health. OR 67-175

MD67-49 ION EXCHANGE PROCESSES FOR THE RECLAMATION OF ACID MINE DRAINAGE WATERS

Pollio, F. and Kunin, R., Environ. Sci. Technol. 1 (3), 235-241 (1967). This process is based on the use of gel anion exchange resin, Amberlite IRA-68, which, used in a column operation, functions in the bicarbonate cycle. The effluent water is aerated and subsequently clarified to give useful water whose quality may be further improved through lime softening prior to clarification. Process data presented include some cost information. OR 67-47

MD67-50 RECOMMENDATIONS FOR WATER POLLUTION CONTROL. RACCOON CREEK BASIN, OHIO

Wheeling Field Station, FWPCA, U.S. Dept. Int., 1967. (81 pp.) Seven subwatershed areas are described in detail. An appendix reports the mine drainage source inventory. Recommendations are made for a mine drainage abatement program. OR 67-144

MD67-51 REPORT TO THE SANITARY WATER BOARD ON POLLUTION OF SLIPPERY ROCK CREEK - VOLUME II

Pa. Dept. of Health, Div. Sanit. Eng. Publ. No. 17, April 1967. 109 pp. In Section I, Chester Engineers give the results of their survey of the acid pollution in Slippery Rock Creek and its tributaries as well as make recommendations, including cost estimates, for pollution abatement. Section II is titled, "The effects of the present water quality on the occurrence and distribution of aquatic life in the Slippery Rock Creek watershed." The qualitative and quantitative chemical and biological analyses were carried out during the summer of 1966 by M. A. Shellgren and J. F. McInroy of Slippery Rock State College and by E. D. Reitz of Clarion State College. Their recommendations for improvement of the watershed are given. OR 67-200

MD67-52 PROCESS OF PURIFYING OR RECOVERING MINE DRAINAGE WATERS AND THE LIKE

Rhodes, J. C., U.S. Pat. 3,347,787 (Oct. 17, 1967). 3 pp. Metallic iron is added with air or oxygen to form ferric sulfate reducing the sulfuric acid content of the water. The ferric sulfate is hydrolyzed to the insoluble basic form. OR 67-129

MD67-53 LAKE HOPE REPORT

Riley, C. V., Based on Field Trip, June 12, 1967. Lake Hope, a state-owned lake developed in 1939 receives drainage from a coal mining area. After an on-site tour of Lake Hope which included collection of some water samples for analysis at Bituminous Coal Research, Inc., a plan of improvement was discussed. Attached is a copy of the report "Lake Hope, Summary and progress report, June, 1957" compiled by the Fish. Management Section of the Ohio Division of Wildlife. OR 67-83

MD67-54 CARING FOR A RIVER

Roe, A. V., Steelways 23 (4), 16-19, (1967). Water is treated for use, and returned to the river at a higher quality level. The use of the acid waters of the Mongahela River by industry, particularly steel mills, is described. OR 67-169

MD67-55 DETERMINATION OF MINE WASTE ACIDITY

Salotto, B. V., Barth, E. F., Ettinger, M. B., and Tolliver, W. E., Water Res. Lab., U.S. Dept. Int., Cincinnati, Ohio, Jan. 1967. 26 pp. These studies show that a reliable measure of total acidity can be obtained at 25°C by oxidizing ferrous iron with hydrogen peroxide and titrating to pH 7.3 with .1N sodium hydroxide solution. Proper selection of sample volume overcomes dilution factors and also is shown to minimize interference of manganese, aluminum, calcium, and magnesium. The method developed was used on samples of mine drainage from the Elkins, West Virginia area. Analyses of field samples with added standard solutions gave recoveries of 98 to 103 percent. Precision based on 5 or more determinations was of the order of 1 percent. OR 67-195

MD67-56 MECHANISM OF BACTERIAL PYRITE OXIDATION

Silverman, M. P. (U.S. Bur. Mines, Pittsburgh, Pa.), J. Bacteriol. 94 (4), 1046-1051 (1967). This is a report of studies made to determine whether the indirect contact or the direct contact mechanism or both take place during the bacterial oxidation of pyrite. In the indirect mechanism, it is proposed that ferric ions are reduced to ferrous ions when they oxidize metal sulfides. Bacteria then oxidize ferrous ions to ferric thus regenerating the primary oxidant. The direct contact mechanism is assumed to require only physical contact between bacteria and sulfide mineral under aerobic conditions. Results of manometric experiments measuring oxygen uptake suggest concurrent operation of both mechanisms. There are 21 references. OR 67-183

MD67-57 ACID MINE DRAINAGE RESEARCH AT THE OHIO STATE UNIVERSITY

Smith, E. E. (Ohio State Univ.), Eng. Ext. Ser. No. 129, Purdue Univ., Proc. 22nd Ind. Waste Conf., 1967. pp 229-240. The first integrated acid mine drainage work at Ohio State University, started in 1956, was a laboratory type project aimed at finding the fundamental mechanism of the sulfide-to-sulfate reaction both chemically and biologically on both a laboratory and "pilot" scale. A number of graphs illustrate the chemical mechanism studies which showed pyrite oxidation rates relative to temperature, oxygen concentration, percent relative saturation, and bacteria concentration. Microbiological studies in catalyzed reactions and pilot scale studies at an actual mine are both discussed. OR 67-202

MD67-58 DEVELOPMENT AND TESTING OF AN INJECTION WELL FOR THE SUBSURFACE DISPOSAL OF ACID MINE WATER

Stefanko, R., Vonder Linden, K., and Tilton, J. G., Pa. State Univ., College Earth Miner. Sci., Dept. Mining, SR-60, Rept. to Pa. Coal Res. Bd. (1967). 58 pp.+ The results of this study were not conclusive because adverse geologic conditions prevented injection of acid mine water into the well. However, a substantial amount of subsurface geologic information was recorded. OR 67-12

MD67-59 POTENTIAL INJECTION WELL STRATA FOR ACID MINE WATER DISPOSAL IN PENNSYLVANIA

Stefanko, R., Vonder Linden, K., and Tilton, J. G., Pa. State Univ., Dept. Mining, SR-66, Rept. to Pa. Coal Res. Bd. (1967). 29 pp. Past practices and the need for waste disposal are reviewed. Subsurface geology of the bituminous and the anthracite coal fields is discussed. The disposal potential of several geologic units is examined and recommendations for procedure are made. OR 67-143

MD67-60 REMOVAL OF IRON FROM MINE DRAINAGE WASTE WITH THE AID OF HIGH-ENERGY RADIATION

Steinberg, M., Pruzansky, J., Jefferson, L. R., and Manowitz, B., Brookhaven Natl. Lab., BNL 11576, 1967. 23 pp. Preliminary experimental data are presented on the removal of ferrous iron from acid mine drainage by neutralization with limestone and oxidation Co^{60} gamma radiation treatment. Two irradiation processes are described. The first is a low intensity, long holdup time system, while the second is a high intensity isotopic source with a very rapid removal and low holdup process. The limestone-radiation process yields a readily separated crystalline precipitate. OR 67-55

MD67-61 REMOVAL OF IRON FROM ACID MINE DRAINAGE WASTE WITH THE AID OF HIGH-ENERGY RADIATION. PART II

Steinberg, M., Pruzansky, J., Jefferson, L. R., and Manowitz, B., Brookhaven Natl. Lab., BNL 12114 (1967). 17 pp. High iron content acid mine water from the Fulton borehole in the Crooked Creek area was used in evaluating the effects of several variables on the process of the oxidation and removal of iron from mine drainage by high energy radiation. At the highest radiation intensity used, the difference

MD67-61 (continued)

in the rate of iron oxidation between irradiated and control samples was much greater and decrease in temperature had a much smaller effect than at lower intensity. Additives and catalysts had little effect on the oxidation rate. Costs were compared for radiation, neutralization, and chemical oxidation processes. OR 67-189

MD67-62 A REVIEW OF CURRENT RESEARCH ON COAL MINE DRAINAGE IN APPALACHIA

Stephan, R. W. and Lorenz, W. C., U.S. Bur. Mines, Area I Miner. Resource Office, Pittsburgh, Pa. (1967). 26 pp. The status of current research on methods for the abatement or control of acid mine drainage is discussed. A literature review of the current research is included. (From authors' abstract) OR 67-148

MD67-63 STREAM POLLUTION BY COAL MINE DRAINAGE IN APPALACHIA

Fed. Water Pollut. Contr. Admin., U.S. Dept. Int. (1967). 279 pp. This is a status report of continuing studies on water pollution by drainage both from deep and surface mines in Appalachia. The general discussion includes the causes of acid formation, effects of acid pollution, chemical and physical methods of evaluating the extent of pollution, and control methods and their costs. Detailed information is given on the sources of pollution and the water quality of the main streams and their tributaries in 18 river basins in Appalachia. OR 67-182

MD67-64 PREVENTION OF WATER POLLUTION BY DRAINAGE FROM MINES

Struthers, P. H., Presented, 5th Meet., Water Develop. Coordinating Comm. Appalachia, Atlanta, Ga., Feb., 1967. 11 pp. Some methods of reducing acid drainage are discussed briefly. The effect of erosion and some means of reducing erosion are also discussed. OR 67-21

MD67-65 SWATARA CREEK BASIN OF SOUTHEASTERN PENNSYLVANIA. AN EVALUATION OF ITS HYDROLOGIC SYSTEM

Stuart, W. T., Schneider, W. J., and Crooks, J. W., U.S. Geol. Surv., Water-Supply Paper 1829, (1967). 79 pp.+ Coal mine drainage in the northern part of the Basin is one of the pollution problems. Maps showing the geology, water availability, physical characteristics, and chemical characteristics of stream flow in the Swatara Creek basin are included. OR 67-132

MD67-66 CURRENT RESEARCH TRENDS IN MINED-LAND CONSERVATION AND UTILIZATION

Sullivan, G. D., AIME Ann. Meet., Los Angeles, Calif., Feb. 1967. Preprint No. 67F65. 18 pp. Mining Eng. 19 (3), 63-67 (1967). Hydrology, including mine drainage and impoundments is one of the subjects discussed. OR 67-11, OR 67-22

MD67-67 SUSQUEHANNA RIVER BASIN COMPACT

Interstate Advisory Comm. Susquehanna River Basin, Harrisburg, Pa., Revised, Jan. 1967. 54 pp. The text of the compact for the creation of a Susquehanna River Basin agency comprising the states of New York and Maryland, the Commonwealth of Pennsylvania, and the United States of America is presented. The aim of the compact is to plan for the conservation, utilization, development, management, and control of the water and related land resources on a regional basis for the greatest benefits for all. OR 67-4

MD67-68 WATER SUPPLY AND WATER QUALITY CONTROL STUDY SOUTH BRANCH AND NORTH BRANCH POTOMAC RIVER BASIN

Mid. Atlantic Reg., FWPCA, U.S. Dept. Int., Rept. to Corps Eng., U.S. Dept. Army, Oct. 1967. 33 pp. The supply, quality, and present and projected use of water in the Appalachia Region of the Potomac River Basin is surveyed and recorded as a

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means of evaluating proposed reservoirs. Mine drainage in the North Branch is noted as a major cause of pollution. Summary data of water quality for two stations on the North Branch are presented. Records of individual samples taken during the month of August 1966 at two other stations are also given. OR 67-196

MD67-69 POLLUTION CONTROL IN MINING AND PROCESSING OF INDIANA COAL

Woodley, R. A. and Moore, S. L., J. Water Pollut. Contr. Fed. 39 (1), 41-49 (1967). The extent of the pollution problem resulting from coal mining in Indiana is discussed and a brief history of the Indiana stream pollution control law is presented. Some pollution control measures used in the state are: flooding final surface mine excavations, diversion of run-off from active mines, rapid conveyance of precipitation and seepage from mines, disposal of acid-producing refuse in surface mine excavations, clarification of coal wash water in settling ponds, reuse of coal wash water, soil coverage of acid-producing refuse disposal sites, and soil coverage of roads containing acid-producing material. OR 67-95

MD67-70 STREAMFLOW REGULATION FOR ACID CONTROL

Young, G. K. and Gitto, L. F. (U.S. Dept. Int., FWPCA), IBM Sci. Computing Symp., Water Air Resour. Management, 1967. 24 pp. This is a computer study of the handling of the available mass of data on stream quality and flow in order to control acid pollution. Examples are given of methods for determining the release of water from dams in the Kiskiminetas River Basin to minimize acid flow into the Allegheny, particularly in the summer when local storms can cause the "flush out" effect which quickly lowers the pH of a stream and can result in fish kills. OR 67-188

MD67-71 COAL MINE DRAINAGE TREATMENT

Young, E. F., Jr. and Steinman, H. E. (Jones & Laughlin Steel Corp.), Eng. Ext. Ser. No. 129, Purdue Univ., Proc. 22nd Ind. Waste Conf., 1967. pp 477-491. The complex nature of the reactions in which mine drainage is formed, the differences in the nature and character of the strata overlying the mines, and the different drainage conditions in different mined areas are pointed out as reasons that there is no typical mine drainage discharge. A variety of approaches to eliminate pollution from mine drainage is illustrated by treatment of the drainage from five different discharge points at three of Jones & Laughlin Steel Corporation's coal mining operations. OR 67-128

MD67-72 ACID MINE DRAINAGE RESEARCH AT BITUMINOUS COAL RESEARCH, INC.

Zawadzki, E. A., AIME Meet., Las Vegas, Nev., 1967. 12 pp. The chemical and physical properties of mine water are given as a background for the discussion of Bituminous Coal Research, Inc., process development studies. These include the lime treatment process, the limestone treatment process, and the sulfide treatment process. There are 20 references. OR 67-190

MD67-73 STATUS OF MINE DRAINAGE TECHNOLOGY

Zawadzki, E. A. (Bitum. Coal Res., Inc.), Attachment B to Boyer, J. F., Jr., Statement before Subcom. Air, Water Pollution, Comm. Public Works, U.S. Senate, July 13, 1967. 33 pp. The chemical, electrochemical, and bacterial formation of both acid and alkaline mine waters is defined in Part 1 of this paper. In Part 2, the treatment processes as summarized by Barthauer are discussed. The methods are evaluated as to their feasibility, specific problems that arise from each one, and, where such data has been available, the cost involved. Part 3 of the paper is concerned with the problems of sludge handling and disposal. There are 62 references. OR 67-179

1968

MD68-1 ACID MINE DRAINAGE ABATEMENT MEASURES FOR SELECTED AREAS WITHIN THE SUSQUEHANNA RIVER BASIN

Gannett Fleming Corddry & Carpenter, Inc., Engineers, Rept. to U.S. Dept. Int., Fed. Water Pollut. Contr. Admin. (1968). 99 pp.+ NTIS, PB 220-158/0. Five study areas in which mining has been carried on extensively are examined and reported on in detail. In each area, active and inactive deep and strip mines are identified, and water flow and acid drainage points are determined. Based on a review of 24 acid mine drainage abatement measures, 8 preventative measures and 1 treatment measure are considered to be effective in one or more of the study areas. A series of abatement plans ranging from treatment alone through various degrees of preventative measures and treatment combined is presented for each study area. Costs are given for all plans. OR 68-197

MD68-2 ACID-MINE DRAINAGE - PILOT PLANT

Baker, R. A. and Wilshire, A. G. (Carnegie-Mellon Univ., Mellon Inst.), Final Rept., Project 4447, for Appalachian Regional Comm. (Aug. 1, 1967 to Nov. 30, 1968). 59 pp. In the pilot apparatus, pyritic and associated mineral strata from actual mines were subject to flow of feed water of known composition under controlled atmosphere. Both horizontal and vertical packed-beds were used. Units seeded with a mixture of cultures of Thiobacillus thiooxidans, Ferrobacillus sulfooxidans, and Ferrobacillus ferrooxidans were compared with non-seeded reactors under aerobic and anaerobic conditions. The microorganisms significantly accelerated the oxidation of ferrous iron and sulfide released from pyrites but apparently did not alter the rate of pyrite dissolution in an aerobic environment. It was concluded that mine sealing will not eliminate acid formation since excluding oxygen does not prevent dissolution of pyrites. OR 68-203

MD68-3 CHEMICAL ASPECTS OF ACID MINE DRAINAGE

Barnes, H. L. (1) and Romberger, S. B. (2) [(1) Pa. State Univ. and (2) Mich. State Univ.], J. Water Pollut. Contr. Fed. 40 (3-Pt. 1), 371-384 (1968). Chemical reactions and their limitations by oxidation potential and pH of mine drainage formation systems are described in detail. Also discussed are several techniques for reducing the acid formation in mines and their chemical limitations: use of bactericides, mine sealing, passivation, sulfate reduction, carbonate treatment, and hydrologic control. The chemistry of neutralization of mine water both by carbonate rocks and by dilution, especially with buffered water are discussed. Several questions and problems encountered in the study of mine drainage have been defined. The leading unknown is what reactions resulting in low pH take place at low oxygen potential where essentially no dissolved oxygen is available. Another question is how ferric oxyhydroxide can be removed from suspension by less costly methods than at present. The problem of precipitation of ferric hydroxide on surfaces of calcium carbonate rocks thereby preventing further neutralization has also been noted. OR 68-158

MD68-4 ANALYSIS OF WATER QUALITY OF THE MAHONING RIVER IN OHIO

Bednar, G. A., Collier, C. R., and Cross, W. P., U.S. Geol. Surv., Water-Supply Paper 1859-C (1968). 32 pp.+ Above Leavittsburg the Mahoning River is affected mainly by mine drainage. Below Leavittsburg, between Warren and Lowellville, Ohio, municipal and industrial wastes, including thermal loading, are added to the river. The report is based on data collected from January 1963 to December 1965. Results of water sample analyses are given in graphs, charts, and tables. There are also maps illustrating the variations in temperature, dissolved oxygen, pH, chloride, sulfate, and calcium carbonate alkalinity throughout the section of the river under study. OR 68-198

MD68-5 WATER RESOURCES OF THE SCHUYLKILL RIVER BASIN

Biesecker, J. E., Lescinsky, J. B., and Wood, C. R., Pa. Dept. Forests Waters, Water Resour. Bull. No. 3 (1968). 198 pp. Mine drainage affects many of the tributaries and the entire main stem. A map shows sampling sites at which pH and specific conductance measurements were made in the spring and fall of 1965. The values are tabulated. Another map and table relate the water quality of coal mine discharge to extent and flow path of underground mine water pools. In this case values determined in spring and fall 1965 are given for amount of discharge, dissolved solids, sulfate, and acidity as H_2SO_4. Tables showing the chemical constituents in streams and in ground-water of the various physiographic sections of the region include amounts of silica, iron, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, nitrate, dissolved solids, hardness as calcium carbonate, and specific conductance. There are 95 references. OR 68-201

MD68-6 APPLICATION OF MINE DRAINAGE CONTROL METHODS

Birch, J. J. (Barnes and Tucker Co.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 372-375. The mine drainage control program has included stream surveys to establish flow patterns and the chemical characteristics of streams; dilution of fair quality water to improve the chemical characteristics; improving mining practices to reduce or eliminate surface and underground waters from the mining operations; determination of the effect of residual iron in treated mine water on a clean stream and the fish population; and studies of aeration, neutralization, and oxidation on laboratory, pilot plant, and full scale installations. OR 68-23

MD68-7 EFFECTS OF SURFACE MINING ON FISH AND WILDLIFE IN APPALACHIA

Boccardy, J. A. and Spaulding, W. M., Jr. (Div. Fishery Serv.), U.S. Dept. Int., Bur. Sport Fisheries Wildlife Resour. Publ. 65 (1968). 20 pp. The general effects of surface mining in Appalachia are described as destruction of vegetation (food and cover for wildlife), land isolated by highwalls around hilltops, and water pollution by acid, sediment, and silt. A team of specialists from six federal agencies surveyed selected sites within the area and part of this report is based on their observations. The effects of mining are summarized for Alabama, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. The state laws regulating surface mining and the amount of reclamation required in each state are noted. OR 68-180

MD68-8 A REVIEW OF THE LITERATURE OF 1967 ON WASTEWATER AND WATER POLLUTION CONTROL: COAL AND COAL MINE DRAINAGE

Boyer, J. F., Jr. (Bituminous Coal Res., Inc.), J. Water Pollut. Contr. Fed. 40 (6), 1158-1162 (1968). This comprehensive review of the literature on coal and coal mine drainage is based on the abstracts published in the 1967 Supplement to the Mine Drainage Abstracts. Material listed presents a general picture of the worldwide extent of mine drainage pollution; the definition of the problem in the United States, particularly the Ohio River Valley; latest studies on the formation of acid mine water; and recent work on treatment procedures. There are 39 references. OR 68-159

MD68-9 BENEFIT-COST ANALYSIS OF SURFACE MINING FOR COAL: RESEARCH METHODS AND RESEARCH NEEDS

Brock, S. M. (W. Va. Univ.), AIME Fall Meet., Minneapolis, Minn., Sept. 18, 1968. Preprint No. 68K355. 13 pp. This paper discusses surface and auger mining costs and uses data obtained from the Myles Job Mine in northern West Virginia. Included are estimates of reclamation costs and mine drainage neutralization using lime. The methodology used in the study is described, and some of the finds on the utility of cost-benefit analysis are summarized. OR 68-211

MD68-10 THE MYLES JOB MINE - A STUDY OF BENEFITS AND COSTS OF SURFACE MINING FOR COAL IN NORTHERN WEST VIRGINIA

Brock, S. M. and Brooks, D. B., W. Va. Univ., Appalachian Cent., Off. Res. Dev., Res. Ser. 1, 1968. 61 pp. This is a detailed cost study of all items pertaining to mining, acid drainage, and reclamation for the Myles Job Mine which produced 47,000 tons of coal - a rather small operation. Very detailed descriptions are given on acid control, spoil bank material handling and revegation. The cost analysis is tabulated in two appendixes. OR 68-210

MD68-11 AVOIDING POLLUTION FROM REFUSE DISPOSAL

Calhoun, F. P. (Rochester & Pittsburgh Coal Co.), Mining Congr. J. 54 (6), 78-80 (1968). In this article some basic principles are given for the building of new refuse piles so that they will not cause problems. Among the important factors are choice of a suitable site and its preparation, including drainage ditches; a size consist that will pack with enough stability to support operation of heavy equipment; prevention of the penetration of water into the pile; and finishing the pile with top soil and vegetation. OR 68-167

MD68-12 TREATMENT OF MINE DRAINAGE WITH LIMESTONE

Calhoun, F. P. (Rochester & Pittsburgh Coal Co.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 386-391. This paper describes the limestone treatment system being used at the R & P Lucerne 3A mine. OR 68-25

MD68-13 AN EVALUATION OF FACTORS AFFECTING ACID MINE DRAINAGE PRODUCTION AND THE GROUND WATER INTERACTIONS IN SELECTED AREAS OF WESTERN PENNSYLVANIA

Caruccio, F. T. (Pa. State Univ.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 107-151. Rock and water samples were collected from two study areas near Clearfield, Pennsylvania; one with mines producing acid mine drainages and the other with mines yielding nonacid drainages. The samples were analyzed and compared to determine the cause of the difference in water quality. Leaching tests showed acid production to be partly dependent on the sulfur content of a sample and greatly influenced by pyrite crystallinity, iron bacteria, and calcium carbonate. Ground waters in the unmined portions of the acid drainage areas had low pH, whereas ground waters in the nonacid mines had negligible sulfate concentrations indicating the stability of pyrite in this region. OR 68-10

MD68-14 PENNSYLVANIA'S ABANDONED MINE DRAINAGE POLLUTION ABATEMENT PROGRAM

Charmbury, H. B., Buscavage, J. J., and Maneval, D. R. (Pa. Dept. Mines Miner. Ind.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. 319-333. Pennsylvania's program for mine drainage pollution abatement is described. Details of the automatic lime treatment plant and its operation on Little Scrubgrass Creek show its successful operation. OR 68-21

MD68-15 MINE DRAINAGE POLLUTION ABATEMENT PENNSYLVANIA STYLE

Charmbury, H. B. and Maneval, D. R. (Pa. Dept. Mines Miner. Ind.), AIME Ann. Meet., New York, N. Y., 1968. Preprint 68F18. 11 pp. The program funded by the state is discussed in detail. A list of the projects gives the contractor and the cost for each one. OR 68-29

MD68-16 GROUND-WATER HYDROLOGY PERTAINING TO SURFACE MINING FOR COAL--SOUTHWESTERN INDIANA

Corbett, D. M., Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 164-189. Cast overburden from surface mining for coal in southwestern Indiana has formed ground-water aquifers capable of storing large volumes of water from precipitation. During the three-year study period, it was found that these

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aquifers reduced flood flows and crests and increased flows during extended dry periods. Data have been analyzed for two tributaries of the Patoka River and three tributaries of Busseron Creek. OR 68-12

MD68-17 COAL MINING EFFECT ON BUSSERON CREEK WATERSHED, SULLIVAN COUNTY, INDIANA

Corbett, D. M. and Agnew, A. F., Ind. Univ., Water Resour. Res. Center, Rept. Invest. No. 2 (1968). 200 pp. The extent of mine drainage pollution in the watershed was determined by analyses of samples collected at eleven stations over a two-year period. The importance of flush outs, i.e., "precipitation sufficient in amount and intensity to cause storm runoff which can drastically change the quality of water in the receiving stream" was emphasized, and runoff and flush-out data are tabulated. OR 68-165

MD68-18 WASTE TIP STABILIZATION IN THE RUHR

Corner, J. T. (Dollery and Palmer, Ltd.), Colliery Guardian 216 (5576), 250-253 (1968). This article describes in detail the cultivation method used in the Ruhr for building and landscaping refuse piles to prevent water and air pollution, erosion, and slippage. OR 68-189

MD68-19 COAL WASTE BANK STABILITY

Davies, W. E. (U.S. Geol. Surv.), Mining Congr. J. 54 (7), 19-24 (1968). Features of spoil banks that reflect their instability are described. Saturation with water is shown to be one of the main causes. Suggestions are given to improve the stability of the piles. OR 68-168

MD68-20 THE ABATEMENT PROGRAM OF PEABODY COAL COMPANY

Deane, J. A. (Peabody Coal Company), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 392-395. The basic philosophy of Peabody's pollution abatement program is prevention, not treatment, and this paper documents their experience in handling make-up water in the preparation plants, run-off from refuse piles, discharges from active and inactive deep mines, and outflows from active, inactive, and abandoned open pit mines. OR 68-26

MD68-21 TURBIDITY MEASUREMENTS AS AN INDICATOR OF SOLIDS CONTENT OF NEUTRALIZED MINE WATER

Deul, M. (U.S. Bur. Mines), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 35-38. For acid mine waters neutralized with lime or limestone, the suspended solids content, as estimated by a Jackson candle turbidity apparatus, diverges greatly from the actual solids content determined gravimetrically. (From author's abstract) OR 68-3

MD68-22 THE AQUATIC ECOLOGY OF TOMS RUN, CLARION COUNTY, PENNSYLVANIA, PRECEDING WATERSHED RECLAMATION

Dinsmore, B. H. (Dept. Biol. Sci.), Clarion State College, Rept. to Pa. Dept. Mines Miner. Ind., Bur. Coal Res.; and Pa. Dept. Health, Bur. Sanit. Eng., Div. Water Quality, Publ. No. 21 (1968). 71 pp. Toms Run, a tributary of the Clarion River, is polluted by acid mine drainage but not severely damaged over its entire length. This report gives the results of biological and chemical analyses of samples taken at 21 stations. Stream quality is compared with one station on the Clarion River and with Cathers Run, a clean stream also a tributary to the Clarion. OR 68-174

MD68-23 PROCESS OF TREATING COAL MINE ACID DRAININGS

Dixon, J. W., U.S. Pat. 3,403,099 (Sept. 24, 1968). 3 pp. This patent describes a method of treating acid mine drainage by the addition of cationic electrolytic polymer, neutralization, and addition of anionic electrolytic polymer in that sequence. OR 68-192

MD68-24 ACID MINE DRAINAGE TREATMENT FACILITIES: CITY OF ALTOONA WATERSHED, PA.

Dobson, R. T., Gwin Engineers, Inc., Prelim. Design Rept., Operations Scarlift Proj. SL-116, to Pa. Dept. Mines Miner. Ind. (1968). 100 pp.+ Since the city's water supply exceeded the maximum limits set by the Pennsylvania Department of Health for iron and manganese and since various potential sources of water were polluted by acid mine drainage, the treatment plant described here was proposed to provide a public water supply. Primary treatment would be by neutralization and secondary treatment by the lime-soda ash method. The feasibility of disposing of sludge either in deep or strip mines is discussed. Cost estimates of the facilities are given. OR 68-190

MD68-25 THE MICROBIAL FLORA OF ACID MINE WATER AND ITS RELATIONSHIP TO FORMATION AND REMOVAL OF ACID

Dugan, P. R., Randles, C. I., Tuttle, J. H., McCoy, B., and MacMillan, C. (Water Resour. Cent.), Ohio State Univ., Res. Proj. Completion Rept., Proj. No. A-002-OHIO U.S. Dept. Int., Office Water Resour. Res., Oct. 1968. 132 pp. Various aspects of the research on the activities of microorganisms in acid mine water are reported in five chapters, which are also being published separately. OR 68-193

MD68-26 EFFICIENCY IN VENTILATION AND DRAINAGE: MINE-DRAINAGE

Coal Age 73 (7), 202-203 (1968). Procedures for handling water are (1) keep the water out of the mine; (2) return to outside by gravity flow; and (3) design for high efficiency pumping. Each procedure is discussed emphasizing the variety of conditions that may apply. The factors relating to low costs of water handling are also considered. OR 68-177

MD68-27 SOME CHARACTERISTICS OF DRAINAGE FROM DEEP BITUMINOUS MINES IN WESTERN PENNSYLVANIA

Emrich, G. H. and Thompson, D. R. (Pa. Div. Sanit. Eng.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 190-222. The varying characteristics of mine drainage are related to the geology of the coal seams which are the source of the drainage. OR 68-13

MD68-28 VENTILATION AND DRAINAGE...PLANNING AND PRACTICE

Flowers, A. E., Coal Age 73 (10), 124-130 (1968). The most efficient and effective methods for controlling water in mines are described. Basic to reducing pollution from acid mine water is quick collection of water in the mines and its immediate removal, keeping it out of contact with acid forming material. OR 68-170

MD68-29 MORAINE STATE PARK MINE DRAINAGE PROJECT

Foreman, J. W. (1) and Tarr, E. G. (2) [(1) Gwin Engineers, Inc. (2) Pa. Dept. Forest. Waters], Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 246-254. The Moraine State Park, now under construction (in Butler County), has 15,000 acres and will have a 3,225 acre lake. Control measures to prevent acid pollution of Lake Arthur include sealing of mines and mine drifts, removal or back fill of exposed acid producing materials, planting, and construction of diversion ditches. Treatment plants will be considered only as a last resort. OR 68-16

MD68-30 AEROBIC - ANAEROBIC OXIDATION OF PYRITES

Halko, E. M. (Dept. Chem. Eng.), M.S. Thesis, Ohio State Univ., 1968. 67 pp. The purpose of this study was to find the kinetics and mechanism of reactions of the oxidation of pyrite in the forming of acid mine water as a step toward being able to prevent acid formation. Both aerobic and anaerobic oxidation of two different types of pyrite, museum grade sample, and sulfur ball, were studied. Results show that aerobic and anaerobic reactions seem to be independent. OR 68-182

MD68-31 CONTROL OF POLLUTION FROM ACTIVE MINES IN PENNSYLVANIA

Heine, W. N. (Dir., Div. Mine Drainage, Pa. Dept. Health), Presented, ORSANCO Eng. Comm., Sept. 12, 1968. 3 pp. The author reviews the activity of the Sanitary Water Board of Pennsylvania in regulating water pollution from mining. OR 68-202

MD68-32 TREATMENT OF MINE DRAINAGE BY INDUSTRY IN PENNSYLVANIA

Heine, W. N. and Giovannitti, E. F. (Pa. Dept. Health, Div. Mine Drainage), 2nd Mid-Atlantic Ind. Waste Conf., Philadelphia, Pa., Nov. 19, 1968. 18 pp. Mine drainage treatment including sludge handling and disposal is discussed with reference to the experience at 5 treatment plants handling drainages produced from four coal seams. In general, the mine drainage treatment plants operating to date can meet the Pennsylvania Sanitary Water Board discharge regulations of 7 mg/l of iron, pH between 6 and 9, and titratable alkalinity which exceeds titratable acidity. However, manganese is difficult to remove without increasing the pH further. OR 68-181

MD68-33 MINE DRAINAGE TREATMENT: STATE OF THE ART AND RESEARCH NEEDS

Hill, R. D., U.S. Dept. Int., FWPCA, Cincinnati, Ohio (1968). 101 pp. After the nature and extent of the problem of pollution of mine drainage are characterized, the following methods of treatment are reviewed: Neutralization, iron removal, ion exchange, reverse osmosis, distillation, electrodialysis, crystallization (freezing), and biological treatment. In each of these areas, research needs are emphasized. Iron removal is noted as a particularly critical problem with many studies other than aeration and alkaline precipitation not tested on a pilot plant scale. Research and development programs on mine drainage treatment sponsored by the Federal Water Pollution Control Administration are listed. There are 53 references. OR 68-150

MD68-34 FACTORS IN THE DESIGN OF AN ACID MINE DRAINAGE TREATMENT PLANT

Holland, C. T., Corsaro, J. L., and Ladish, D. J. (W. Va. Univ.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 274-290. The lime treatment plant was used to investigate introduction of the feed water to the plant, neutralization, oxidation, sludge settling, sludge handling and disposal, land requirements, and costs. Two drainages of different quantity and quality were used in the study. OR 68-19

MD68-35 RESEARCH ON ACID MINE DRAINAGE CONTROL

Holland, C. T., Corsaro, J. L., McGlothlin, C. W., and Ladish, D. J. (W. Va. Univ.), W. Va. Coal Mining Inst. Ann. Meet., White Sulphur Springs, W. Va., 1967 (1968). pp 115-148. This paper describes the two year research program established by Northern West Virginia Coal Association at the School of Mines, West Virginia University. The hydrology of the area is reviewed both for control of water infiltration and to determine central locations for treatment plants. The experimental treatment plant uses feed water of different characteristics from two mines. A flow sheet and description of the plant are given. Tables show the analyses of feed and overflow water for the initial and a later period of operation. Sludge settling, handling, and disposal are being investigated. Cost estimations for neutralizing highly, moderately, and weakly acid water are given. OR 68-196

MD68-36 HOW J&L IMPOUNDS 40,000 GALLONS OF SLUDGE PER DAY

Jones, D. C., Coal Mining Process. 5 (6), 52-54 (1968). Discharge at No. 1 Airshaft of Shannopin Mine which has a pH of 2.4-3.0 and a high ferrous iron content was successfully treated by aeration following neutralization. Resulting sludge is stored in two lagoons which are used alternately so that the out of service lagoon can be drained and the sludge given a chance to compact as much as possible by drying. OR 68-149

MD68-37 COAL MINE DRAINAGE TREATMENT

Jukkola, W. H., Steinman, H. E., and Young, E. F., Jr. (Jones & Laughlin Steel Corp.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 376-385. The drainage from the mines of the Vesta Shannopin Coal Division is varied in quantity and composition. The variety of approaches required to eliminate pollution is illustrated by the treatment of the drainage from four different discharge points. OR 68-24

MD68-38 CONSOLIDATION COAL COMPANY'S ACHIEVEMENTS IN ENVIRONMENTAL CONTROL

Karkaria, N. J. (Consolidation Coal Co.), Mining Congr. J. 54 (9), 46-51 (1968). Included are descriptions of control of refuse pile seepage and runoff; treatment of acid and alkaline mine drainages; impoundment of water in strip pits; and research on microbial oxidation of ferrous iron. OR 68-143

MD68-39 AN EXPERIMENTAL STUDY OF FERROUS IRON OXIDATION IN ACID MINE WATER

Kim, A. G. (U.S. Bur. Mines), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 40-45. Samples of natural mine water were studied to determine the effect of aeration upon the rate of oxidation. Eight 1-liter samples were used for each test. Four were aerated at rates of 200 cc/l/min and 2,000 cc/l/min; two were in open containers to allow normal oxygen diffusion from the air into the water and two were in closed containers with only the dissolved oxygen originally present in the water. Aeration was found to have no beneficial effect upon a low ferrous iron water (34 ppm) because the water had an adequate amount of dissolved oxygen. It did decrease the time necessary for complete oxidation in waters with 175 to 260 ppm ferrous iron, evidently by keeping the water saturated with dissolved oxygen. (From author's abstract) OR 68-5

MD68-40 AN INTEGRATED MONITORING SYSTEM FOR WATER QUALITY MANAGEMENT IN THE OHIO VALLEY

Klein, W. L., Dunsmore, D. A., and Horton, R. K. (Ohio River Valley Water Sanit. Comm.), Environ. Sci. Technol. 2 (10), 764-771 (1968). The robot monitor system of fourteen stations and a data processing center is described. It measures pH, oxidation-reduction potential, chloride, dissolved oxygen, conductivity, temperature, and solar radiation, although all measurements are not made at each station. Experience has shown that hourly sampling is adequate for evaluating variations in water quality and that telemetering is preferable to onsite recording of data. An example of a practical use of the system was the tracing of an acid slug and showing that it was the cause of two fish kills hundreds of miles and several weeks apart. OR 68-172

MD68-41 DESIGN OF MINE DRAINAGE TREATMENT PLANT AT MOUNTAINEER COAL COMPANY (DIVISION OF CONSOLIDATION COAL COMPANY)

Kosowski, Z. V. and Henderson, R. M., Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 396-399. Some of the design features and capital expenditures at a mine drainage treatment plant under construction at the Williams Mine near Enterprise, W. Va., are summarized. The treatment plant is designed for 720,000 gpd of mine drainage characterized by pH 6.5; alkalinity, 252 mg/l; and iron, 109 mg/l. The treatment plant includes a mechanical flocculator, with flocculating basins in each of the settling lagoons. OR 68-27

MD68-42 ANALYTIC METHODS REVIEW AND SAMPLING PROCEDURES AS RELATED TO A STATE CONTROL AGENCY

Kupiec, A. R. (Pa. Dept. Health), Second Symp. Coal Mine Drainage Res., Pittsburgh, Pa., 1968. 6 pp. Good sampling technique is described. Specific ions have been selected by the Health Department to determine the pollutional characteristics of mine drainage. The methods for determining these ions and the other characteristic parameters are discussed. OR 68-4

MD68-43 MINE DRAINAGE CONTROL AT THE CHINOOK MINE

Lawson, A. E. (Ayrshire Collieries Corp.), Eng. Ext Ser. No. 132, Purdue Univ., Proc. 23rd Ind. Waste Conf., 1968. pp 1018-1020. The two types of drainage waters of the Chinook Mine near Staunton, Indiana, are from the pit areas and from the coal preparation plant. The water from 15 water sample stations on the receiving streams is collected monthly and analyzed for pH, total iron, and sulfate. The control of drainage is carried out according to the 1967 reclamation laws; grading is specifically described. OR 68-194

MD68-44 CLEAN STREAMS PROGRESS IN PENNSYLVANIA

Lyon, W. A. (Pa. Div. Sanit. Eng.), Water Pollut. Contr. Assoc. Pa. Mag. 1 (1), 8, 10, 12-13 (1968). The work of the Pa. Sanitary Water Board, including its efforts toward mine drainage abatement, is described. OR 68-98

MD68-45 THE LITTLE SCRUBGRASS CREEK AMD PLANT

Maneval, D. R. (Pa. Dept. Mines Miner. Ind.), Coal Mining Process. 54 (9), 28-32 (1968). The fully-automated neutralization process acid mine drainage treatment plant on Little Scrubgrass Creek, Venango County, in Western Pennsylvania was developed by the Commonwealth and is being tested on a "low iron" stream. The equipment is described with diagrams showing operating details of the plant. Tables contrast the water quality of the creek before and after treatment. Estimated capital and construction costs and monthly operating expenses are given. Studies by the Pennsylvania Fish Commission, approximately three months after the plant was considered to be performing satisfactorily, showed that the creek was being restored. OR 68-169

MD68-46 MINE DRAINAGE RESEARCH PROGRAM OF THE FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

Martin, E. J. and Hill, R. D. (FWPCA), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 46-63. The development of treatment technology under the Federal Water Pollution Control Administration mine drainage control program is discussed. OR 68-6

MD68-47 THE ACTIVITY OF MICROORGANISMS IN ACID MINE WATER. II. THE RELATIVE INFLUENCE OF IRON, SULFATE AND HYDROGEN IONS ON THE MICROFLORA OF A NON-ACID STREAM

McCoy, B. and Dugan, P. R. (Ohio State Univ.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 64-79. The effect of chemical variable on growth and inhibition of four bacterial isolates from a non-acid stream was examined. Correlation analysis using survival of microorganism under the experimental conditions as a dependent variable and the ion concentrations as independent variables was performed. The general conclusion was that test organisms could grow when pH is above 5.3, iron from 1-100 μg-ml, and sulfate from 50-500 μg/ml. OR 68-7

MD68-48 PRELIMINARY REPORT ON ACID MINE DRAINAGE RESEARCH AT WEST VIRGINIA UNIVERSITY

McGlothlin, C. W., Jr., Corsaro, J. L., Ladish, D. J., and Holland, C. T., W. Va.

MD68-48 (continued)

Univ. Rept. for Northern W. Va. Coal Assoc. (undated). 44 pp. The effects of mining hydrology of northern West Virginia on mine drainage formation and the development of mine drainage treatment processes are discussed. OR 68-95

MD68-49 A PILOT PLANT STUDY OF THE AUTOPURIFICATION OF SEWAGE EFFLUENT-ACID MINE DRAINAGE MIXTURES

McLean, D. C. and Wernham, J. A., Pa. State Univ., Inst. Res. Land Water Resour., Res. Publ. No. 55 (1968). 42 pp. Laboratory work showing reduction in iron, phosphate, chemical oxygen demand, and acidity with mixtures of sewage effluent and acid mine drainage was confirmed by the pilot plant study described here. OR 68-164

MD68-50 FACTORS IN NEUTRALIZING ACID MINE WATERS WITH LIMESTONE

Mihok, E. A. and Chamberlain, C. E. (U.S. Bur. Mines), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 265-273. A continuous limestone neutralization pilot plant capable of handling 100 gpm of acid-iron water was designed, constructed, and operated to study some of the factors controlling neutralization and oxidation processes. Rapid neutralization of acid water was achieved with the use of coarse crushed limestone in a rotary-kiln-type reactor. Subsequent aeration of neutralized water from the reactor removes soluble ferrous iron at the rate of 1 to 4 ppm per minute. Although the pH of the neutralized waters ranged from 6.5 to 7.5, sufficient alkaline activity was not achieved to bring about mass precipitation of insoluble ferrous hydroxide, despite an excess of finely divided limestone remaining in suspension. (From authors' abstract) OR 68-18

MD68-51 LIMESTONE NEUTRALIZATION--A LOW COST AND EFFECTIVE TREATMENT FOR ACID MINE WATERS

Mihok, E. A. and Deul, M. (U.S. Bur. Mines), Coal Age 73 (12), 65-70 (1968). The Bureau of Mines method of neutralization of acid mine drainage is based on the use of a fine limestone slurry in a revolving reactor. OR 68-151

MD68-52 MINE WATER RESEARCH: THE LIMESTONE NEUTRALIZATION PROCESS

Mihok, E. A. (1), Deul, M. (1), Chamberlain, C. E. (1), and Selmeczi, J. G. (2) [(1) U.S. Bur. Mines, (2) Dravo Corp.], U.S. Bur. Mines, RI 7191 (1968). 23 pp. The pilot plant set up for the limestone neutralization of acid waters containing iron in solution is described in detail. A limestone slurry of fine particles is produced in a revolving drum and added to the mine water to be treated. Figures are given showing that the method is low in cost. The resulting sludge settles more rapidly and compacts more highly than lime sludge. OR 68-166

MD68-53 MINE DRAINAGE POLLUTION STUDY

Washington County Planning Comm., Pa., Mar. 1968. (14 pp.) The source and extent of mine drainage pollution in Washington County, Pa. have been presented graphically, and are shown on maps of watersheds of the county. OR 68-52

MD68-54 MINE AIR SEALING: A PROGRESS REPORT

Moebs, N. N. (U.S. Bur. Mines), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 255-264. A small, abandoned, above drainage coal mine in the Upper Freeport coal bed in Western Pennsylvania, sometimes referred to as Decker No. 3 mine, was air sealed in 1966 to determine if the acidity and iron of the discharge could be reduced. The mine effluent, flow rate, and quality have been monitored continuously since 1963. Since the mine was sealed, the average total acidity of the effluent has continued to decrease despite an oxygen level of 16 to 18 percent and lack of any differential air pressure across the seal. OR 68-17

MD68-55 MORAINE STATE PARK WATERSHED AREA, BUTLER COUNTY

Gwin Engineers, Inc., Altoona, Pa., Rept. to Pa. Dept. Mines Miner. Ind., Mine Drainage Proj. MD-8A (1968). 109 pp. This report includes the results of the extensive survey of the geography, geology, and mining conditions of the area; identity of sampling points and flow and chemical quality of water at these points; drilling logs for the mineral exploration project; and recommendations for abatement. OR 68-92

MD68-56 MOUNTAINEER WATER TREATMENT PLANT HIGHLY EFFICIENT

Consol News 7 (6), 22-24 (1968). The water treatment process at the Mountaineer Coal Company Division of Consolidation Coal Company is described. Since the mine discharge is alkaline, the water is aerated to precipitate out iron and hold in lagoons while the sludge settles out. Clear water is allowed to overflow into a creek. Sludge disposal is a serious problem. The treatment plant is equipped with lime storage and feeding facilities so that acid drainage from a nearby discharge point can also be treated. OR 68-153

MD68-57 WATER RESOURCES OF THE MIDDLESBORO AREA, KENTUCKY

Mull, D. S. and Pickering, R. J. (U.S. Geol. Surv.), Ky. Geol. Surv., Rept. Invest. No. 9, Series X, (1968). 51 pp, 7 plates. This report describes the hydrology and hydrography of the area. The effect of acid mine drainage on some streams and some ground water supplies is shown by high iron and high sulfate content. Some water supplies have been developed from water impounded in abandoned coal mines. Maps, tables, and graphs give in detail the availability and quality of water in the area. OR 68-184

MD68-58 NEUTRALIZED AMD OVERCOMES PLANT WATER SHORTAGE

Coal Mining Process. 5 (2), 40-41 (1968). Three separate drainage discharges at the Pittsburgh Coal Company's Renton Mine are combined to provide an adequate supply of preparation water after lime neutralization. OR 68-86

MD68-59 ORSANCO 1968: 20TH YEARBOOK

Ohio River Valley Water Sanitation Comm., Cincinnati, Ohio, 1968. 45 pp. Water quality in the Ohio River and some of its tributaries during 1967 are summarized. The locations of the electronic monitors, the Water Users Committee stations, and the U.S. Geological Survey stations are mapped. One conclusion related to the mine drainage problem is that the Monongahela is the most acid stream in the Ohio River Basin with pH values of less than 5 recorded on 202 days of the year. OR 68-161

MD68-60 THE EFFECTS OF ACID STRIP-MINE EFFLUENTS ON THE ECOLOGY OF A STREAM

Parsons, J. D., Arch. Hydrobiol. 65 (1), 25-50 (1968). Data collected at 11 stations over 27 months showed that acid mine drainage from spoil and strip mine lake overflow affected Cedar Creek in Boone and Callaway Counties, Missouri continuously in one area and intermittently, depending on rainfall and streamflow, further downstream. Community structure (species diversity and number) in six areas was related to the degree of pollution of that area of the stream. Intermittent highly acid flows had most effect on communities in less polluted areas, but these communities also showed recovery after pollution episodes. OR 68-212

MD68-61 TOXICITY OF ACID MINE WATER TO TWO SPECIES OF SUNFISH

Pegg, W. J., M.S. Thesis, W. Va. Univ., 1968. 106 pp. Fish collected from the Monongahela River and pond fish were subjected to combinations of acid mine water, sulfuric acid, river water, constituted river water, and pond water. Static, progressively increasing concentration, and constant flow-through methods of acid toxicity testing were employed, with the flow-through system of testing found to be

MD68-61 (continued)

superior. All 24 hour, 48 hour, and 72 hour TL_m values from the flow-through exchange system for river pumpkinseeds, and river and pond blue gills ranged from 38 to 73 mg/l as $CaCO_3$ cold total acidity, or from pH 3.54 to 3.19. The physical responses and appearance of sunfish under the stress of acid water indicated that mortality resulted from asphyxiation, despite normal levels of dissolved oxygen. (From author's abstract) OR 68-213

MD68-62 PENNSYLVANIA'S TEN YEAR MINE DRAINAGE POLLUTION ABATEMENT PROGRAM FOR ABANDONED MINES

Pa. Dept. Health, Sanit. Water Bd., Progr. Rept., 3rd ed., April 1, 1968. 11 pp. Pennsylvania's ten year program for abating pollution from abandoned mines is outlined, and the current status is reviewed. OR 68-53

MD68-63 POLLUTION CAUSED FISH KILLS--1967

U.S. Dept. Int., Federal Water Pollut. Contr. Admin., CWA-7 (1968). 17 pp. This is a summary of the reports of fish kills in 1967. Mining operation and the problem of acid drainage is reported as being responsible for the third highest number of fish killed. OR 68-187

MD68-64 RECOMMENDED WATER QUALITY STANDARDS FOR SURFACE WATERS--PITTSBURGH AREA STREAMS IN THE OHIO RIVER BASIN

Pa. Dept. Health, Div. Sanit. Eng., Rept. to Sanit. Water Bd., July 24, 1968. 23 pp. This is part of the ongoing stream classification program and covers the surface waters of the Ohio River basin in the Pittsburgh area that flow through Allegheny, Armstrong, Butler, Washington, and Westmoreland Counties. OR 68-99

MD68-65 STUDIES ON THE KINETICS OF IRON(II) OXIDATION IN MINE DRAINAGE

Rozelle, R. B., Wilkes College, Wilkes-Barre, Pa., Final Rept. to U.S. Dept. Int., Fed. Water Pollut. Contr. Admin., Sept. 25, 1968. 135 pp. The purpose of this investigation is to obtain information on the rate of ferrous iron oxidation in mine water in impoundments and in streams, and to develop and test a mathematical model for the prediction of water quality following interaction of acid and alkaline streams. The appendix gives methods and detailed results of analyses as well as maps of stream sampling points. OR 68-186

MD68-66 STUDIES ON THE REMOVAL OF IRON FROM ACID MINE DRAINAGE WATER

Rozelle, R. B. and Simpson, D. G., Wilkes College, Final Rept. to Pa. Coal Res. Bd., 1968. 109 pp. Section 1 reviews the basic chemistry of iron in aqueous solution applicable to mine drainage. Section 2 describes methods reported in the literature of removing iron from mine drainage or from aqueous solution. In sections 3, 4, and 5 aspects of the use of ozone for iron removal are discussed. The experimental methods used for analysis of mine drainage are described in the appendix. OR 68-108

MD68-67 REVERSE OSMOSIS FIELD TESTING ON ACID MINE WATERS AT NORTON, WEST VIRGINIA

Rusnak, A. and Nusbaum, I., Gulf General Atomic, Final Rept. to U.S. Dept. Int., Office Saline Water (1968). 58 pp. This study reports results of runs made on aerated, untreated mine water, as well as on mine drainage neutralized to more than pH 6. In general, the reverse osmosis process is feasible for untreated mine water; however, severe calcium sulfate fouling can be expected when mine waters neutralized to a pH of 6 with lime are operated at recoveries approaching 75 percent. Details of the apparatus, of the chronology of the program, of the methods used for testing, and of the results are given in full. OR 68-183

MD68-68 REDUCTION OF ACID PRODUCTION IN COAL MINES WITH USE OF VIABLE ANTI-BACTERIAL AGENTS

Shearer, R. E., Everson, W. A., and Mausteller, J. W., Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 98-106. Production of acid has been inhibited in the laboratory in piles of coal washed by streams of tap water and inoculated at widely spaced intervals with waters previously found inhibitory to acid-producing bacteria. Acid produced in uninoculated piles averaged 3.3 times as much over a 75-day period and was 31 times as much during one 3-day period as produced in the inoculated piles. Tests showed that the inhibition is microbial rather than chemical, but the specific agent was not identified. OR 68-9

MD68-69 DEVELOPMENT OF A NATURAL LABORATORY FOR THE STUDY OF ACID MINE DRAINAGE PRODUCTION

Shumate, K. S. and Smith, E. E., Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 223-235. McDaniel's Mine, a small drift mine has been equipped with instruments to permit a detailed study of the influence of oxygen concentration, microbiological factors, and hydrologic features on the rate of pyrite oxidation. OR 68-14

MD68-70 KINETICS OF THE OXIDATION OF FERROUS ION

Singer, P. C. and Stumm, W. (Harvard Univ.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 12-34. Various natural agents, such as clays and minerals, copper, manganese, and sulfate, which might serve a catalytic effect on the oxidation were investigated. An attempt was made to correlate the laboratory results with observations made in acid mine streams. The oxidation of iron pyrite by ferric iron at low pH occurs at a significantly more rapid rate than the soluble Fe(II) oxidation. It is believed, therefore, that the FE(II) oxidation is the rate determining step in the release of acidity to mine waters. FE(III) released by this oxidation is then available as an oxidant for FeS_2. OR68-2

MD68-71 INTERACTION OF TREATED COAL WITH DILUTE ACID SOLUTIONS

Sloughfy, J. L. (Dept. Miner. Prep.), M.S. Thesis, Pa. State Univ., 1968. 170 pp. This study was carried out to elucidate the findings of Lovell and Reese that coal could reduce the acidity and iron content of mine drainage. Coals with a proven response to acid solutions were used. Reduction of acidity by mineral constituents of coal was verified. Further reduction of acidity by coals which had been activated by steam at 750 to 800°C was indicated. OR 68-200

MD68-72 ACID MINE DRAINAGE RESEARCH AT THE OHIO STATE UNIVERSITY

Smith, E. E. (Ohio State Univ.), Presented, Ohio River Valley Water Sanitation Comm., Air-ground Tour Ohio Mines, Sept. 11, 1968. 10 pp. The significant results of projects completed since 1956 at Ohio State University and their relation to present or proposed work are discussed. Vapor phase oxidation of pyrite mineralogical studies to account for the difference in reactivity of various pyritic materials; and microbial studies are covered. The McDaniels mine which has been characterized and instrumented to permit detailed measurement of various controlled conditions and the effects of the change in conditions is described. OR 68-163

MD68-73 SULFIDE TO SULFATE REACTION STUDIES

Smith, E. E., Shumate, K. S., and Svanks, K. (Ohio State Univ.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 1-11. The physical and chemical parameters of the kinetics of the sulfide-to-sulfate reaction are discussed. Experimental observations for two types of pyrite oxidation, aerobic and ferric ion (anaerobic), are presented, and a possible mechanism described. OR 68-1

MD68-74 SWATARA CREEK WATERSHED ABATEMENT PROJECT

Smith, G. E. (Pa. Dept. Mining Miner. Ind.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 236-245. Control of mine drainage flowing into several tributary streams of the Swatara Creek Watershed includes rerouting of several streams, reconditioning sections of stream beds, installing 72-inch diameter concrete flumes across strip mine pits, and back filling. OR 68-15

MD68-75 LAGOONS IN THE COAL MINING INDUSTRY

Smith, G. N. (Heriot-Watt Univ., Edinburgh, U.K.), Colliery Guardian 216 (5581), 471-472 (1968). Effluent from the mining or washing of coal may be discharged into lagoons made in existing spoil heaps. The article gives guidelines for predicting the behavior of water and its seepage path through the spoil heap in order to analyze the factor of safety against slippage. OR 68-155

MD68-76 FISH DISTRIBUTION AND ACID MINE POLLUTION IN THE MONONGAHELA RIVER MAIN STEM OF WEST VIRGINIA

Sotak, M. J., M.S. Thesis, W. Va. Univ., 1968. 56 pp. A twenty-nine mile section of the Monongahela River and several clean and acid tributaries were studied in 1965 and 1966. Data were obtained for fish distribution, pH, acidity, hardness, iron, turbidity, and water temperature. Graded reduction in total numbers of species corresponding to gradients of decreasing pH occurred. The Monongahela River was found to be chronically acid with a pH of 4.5 or less during eight months of the year. The brown bullhead was considered to be the only acid tolerant species. The bluegill, pumpkin-seed sunfish, and green sunfish were considered marginally tolerant. Minnows and suckers were found to be intolerant of low pH and were largely confined to backwaters with pH values of 5.0 or greater. (From author's abstract) OR 68-214

MD68-77 SOURCES OF COAL MINE DRAINAGE POLLUTION. RACOON CREEK WATERSHED, PENNSYLVANIA

Wheeling Field Station, FWPCA, U.S. Dept. Int. Work Document No. 28 (1968). 45 pp. Analyses of water samples from 157 identified mine drainage sources and from 12 stream stations are reported. Most of the mine drainages are acid and contribute to the acidity of Raccoon Creek and its tributaries. OR 68-145

MD68-78 SOURCES OF COAL MINE DRAINAGE POLLUTION. WHEELING CREEK WATERSHED, OHIO

Wheeling Field Station, FWPCA, U.S. Dept. Int. Work Document No. 25 (1968). In the field studies, samples were collected from 120 mine drainage sources, identified as to location, type of mining operation and whether active or inactive. Although mine discharges to Wheeling Creek tributaries were significant, the creek itself was found to be alkaline over its entire length. Mine drainage effects were evident from orange precipitate in various areas and in high sulfate and specific conductance at a sampling station near the mouth of the creek. OR 68-111

MD68-79 REMOVAL OF IRON FROM ACID MINE DRAINAGE WASTE WITH THE AID OF HIGH ENERGY RADIATION

Steinberg, M., Pruzansky, J., Jefferson, L. R., and Manowitz, B., Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 291-318. This work was performed under the auspices of the U.S. Atomic Energy Commission. Experimental results on the Co^{60} gamma radiation oxidation and removal of ferrous iron from Fulton Borehole acid mine drainage (488 ppm FE^{++} and pH = 3.35) are presented and compared with limestone neutralization. OR 68-20

MD68-80 REMOVAL OF IRON FROM ACID MINE WITH THE AID OF HIGH ENERGY RADIATION. PART III

Steinberg, M., Pruzansky, J., Jefferson, L. R., and Manowitz, B., Brookhaven Natl. Lab., BNL 12115 (1968). 6 pp. Agitation and aeration of mine water mixed with a large excess of crushed limestone resulted in high rates of ferrous iron removal. The tests were carried out at approximately 10 C to simulate field conditions. Mechanical agitation, particle size, and ratio of limestone to mine drainage also influenced the process. It is concluded that the increase of iron removal rate by irradiation over the rate of iron removal with this process is not great enough to justify the cost of irradiation. OR 68-199.

MD68-81 COAL MINE DRAINAGE TREATMENT

Steinman, H. E. (Vesta-Shannopin Coal Div., Jones & Laughlin Steel Corp.), 40th Ann. Conf. Water Pollut. Contr. Assoc. Pa., University Park, Pa., 1968. 9 pp. Mine drainage control of the Vesta-Shannopin Coal Division includes neutralization of acid drainage; aeration of an alkaline, high iron drainage; and water handling to minimize contact with acid forming material. OR 68-146

MD68-82 SURVEY OF COSTS ON METHODS FOR CONTROL OF ACID MINE DRAINAGE POLLUTION

Stephan, R. W. and Lorenz, W. C., U.S. Bur. Mines, Area I Miner. Resour. Office, Pittsburgh, Pa. (1968) 35 pp. Capital investment and operating costs are given for neutralization, iron removal, demineralization, and physical disposal by deep well injection. Cost data are also presented for the reclamation of land disturbed by surface mining. OR 68-50

MD68-83 HYDROLOGY OF SURFACE MINING--A CASE STUDY

Sternberg, Y. M. and Agnew, A. F. (Ind. Univ.), Water Resourc. Res. 4 (2), 363-368 (1968). A mathematical model representing a strip mined area is formulated and analyzed. Solutions are obtained for the changes in ground water elevation and ground water flow that would occur in response to a uniform rate of deep percolation over the spoil bank. The solutions developed are for a bounded one dimensional aquifer (spoil bank) where the water level in the last cut (ditch) is a function of time described by an error function. The solution for the ground water flow can be used to forecast maximum and minimum flows from the spoil bank to the last cut. (From authors' abstract) OR 68-100

MD68-84 ION-EXCHANGE TREATMENT OF ACID MINE DRAINAGE

Sterner, C. J. and Conahan, H. A. (Bethlehem Steel Corp.), Eng. Ext. Ser. No. 132, Purdue Univ., Proc. 23rd Ind. Waste Conf., 1968. pp 101-110. A continuous countercurrent ion exchange pilot plant was operated to remove iron cations from acid mine drainage containing about 270 ppm of ferric iron and 1,375 ppm total acidity. A strong acid, styrene-based cation resin, cross-linked with divinyl benzene, was used as the ion exchange medium, and sodium chloride was used as the resin regenerant. By this treatment the cations, including dissolved iron, are concentrated into a waste stream which is only 1.7 percent of the volume of the original stream. The operation of the 1 gpm pilot plant is described, the results of the tests are given and methods for handling the waste regenerant stream are discussed. Because of the wide variation in chemical composition, material costs given for this pilot plant operation cannot be applied directly to other installations. OR 68-56

MD68-85 STREAM POLLUTION BY COAL MINE DRAINAGE, CAPTINA CREEK BASIN, OHIO

Wheeling Field Station, FWPCA, U.S. Dept. Int., Work Document No. 23 (1968). 14 pp. In the field study of Captina Creek, a tributary to the Ohio River, twelve points of mine drainage were located and documented as significant sources of mineralized discharges. Results of analyses of stream samples and mine discharges are tabulated. OR 68-35

MD68-86 STREAM POLLUTION BY COAL MINE DRAINAGE--UPPER OHIO RIVER BASIN

Wheeling Field Station, FWPCA, U.S. Dept. Int., Work Document No. 21 (1968). 111 pp. Water quality data from sampling stations on the Allegheny, Monongahela, Beaver, Muskingum, Hocking, Little Kanawha, Kanawha, Scioto, Guyandotte, Big Sandy, and Ohio Rivers are summarized. OR 68-64

MD68-87 HYDROGEOLOGIC CONSIDERATIONS FOR SEALING COAL MINES

Thompson, D. R. and Emrich, G. H. (Pa. Dept. Health, Div. Sanit. Eng.), 40th Ann. Conf. Water Pollut. Contr. Assoc. Pa., University Park, Pa., 1968. 5 pp. After describing early mine sealing experiments, the authors discuss the water-tight mine seal method of preventing acid mine drainage. The hydrologic and geologic factors that must be considered if a water-tight seal is to be successful are pointed out. The method of developing the mine itself can determine whether or not the water-tight seal will be effective. OR 68-152

MD68-88 TREATMENT OF MINE DRAINAGE DISCHARGES

Gannett Fleming Corddry and Carpenter, Inc., Rept. to Pa. Coal Mining Assoc., April 1968. 9 pp.+ This report has been compiled to provide information to assist mine operators to decide upon a suitable neutralization and iron oxidation. A list of the common alkalis which may be used to neutralize mine drainage provides extensive information about the advantages and disadvantages of each. OR 68-106

MD68-89 ACTIVITY OF MICROORGANISMS IN ACID MINE WATER. 1. INFLUENCE OF ACID WATER ON AEROBIC HETEROTROPHS OF A NORMAL STREAM

Tuttle, J. H., Randles, C. I., and Dugan, P. R. (Ohio State Univ.), J. Bacteriol. 95 (5), 1495-1503 (1968). The microorganisms of a stream contaminated by acid drainage from a gob pile were compared to the organisms of a nearby, nonacid stream. The nonacid stream contained relatively low numbers of acid tolerant heterotrophic microorganisms which survived and increased when the stream became acid. Iron and sulfur oxidizing bacteria were found wherever mine water entered a stream system. A laboratory study in which the environmental variables were controlled substantiated the field data. OR 68-160

MD68-90 ALTERNATIVE ECONOMIC RESPONSES TO THE ACID MINE DRAINAGE PROBLEM IN APPALACHIA

Tybout, R. A., Ohio State Univ., Water Resour. Cent., Proj. Completion Rept. to U.S. Dept. Int., Office Water Resour. Res. (1968). 42 pp. The cost-benefit analysis is based on empirical data from Pennsylvania mines and considers costs of treatment and sealing and secondary costs. Benefits are found for municipal water treatment, industrial water use and recreation as well as for several secondary benefits. The problem of predicting the quality and quantity of mine drainage from geologic, hydrologic and mining conditions was also studied. OR 68-137

MD68-91 A COST-BENEFIT ANALYSIS OF MINE DRAINAGE

Tybout, R. A. (Ohio State Univ.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 334-371. Estimates of abatement costs have been prepared for abandoned and active mines aggregated on a county-by-county basis in Pennsylvania. Inferences are drawn for costs by classifying mines as to type of operation, coal seam, and associated geological conditions. Secondary costs in the form of unemployment and derived income effects of unemployment are estimated with the aid of community multipliers and coal demand functions from several sources. To take account of approximations in the analysis, ranges of costs are given, county-by-county. Estimates of benefits from abatement are made on a selective basis. These include benefits to municipal water works and certain industries. Recreational benefits are available only in selected cases where state-planned recreation projects are linked to mine drainage abatement. OR 68-22

MD68-92 INFLUENCE OF TIME AND PRECIPITATION ON CHEMICAL COMPOSITION OF SPOIL DRAINAGE

Vimmerstedt, J. P. and Struthers, P. H. (Ohio Agr. Res. Develop. Cent.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 152-163. Spoil material from 19 Ohio strip mines, placed in lysimeters, has produced drainage containing large and variable amounts of oxidation and secondary reaction products. During an eight-year period, sulfate-salt production has generally declined with continued weathering. Salts accumulated in the spoils during periods of low moisture, and were leached out during subsequent periods of higher precipitation. The relative proportions of calcium, magnesium, sodium, potassium, manganese, iron, and aluminum changed as weathering and leaching proceeded. OR 68-11

MD68-93 GROUND-WATER HYDROLOGY OF THE MONONGAHELA RIVER BASIN IN WEST VIRGINIA

Ward, P. E. and Wilmoth, B. M. (U.S. Geol. Surv., Water Resour. Div.), W. Va. Geol. Econ. Surv., River Basin Bull. 1 (1968). 59 pp. The geology, ground water availability, and water quality of the region is presented. Acid mine drainage is discussed as one of the effects of surface and deep mining on hydrology and also as one of the water quality problems of the area. OR 68-173

MD68-94 RECORDS OF WELLS, SPRINGS, AND TEST BORINGS, CHEMICAL ANALYSES OF GROUND WATER, AND SELECTED DRILLERS' LOGS FROM THE MONONGAHELA RIVER BASIN IN WEST VIRGINIA

Ward, P. E. and Wilmoth, B. M. (U.S. Geol. Surv., Water Resour. Div.), W. Va. Geol. Econ. Surv., Basic Data Rept. No. 1 (1968). 73 pp. This is a companion volume to River Basin Bulletin 1 "Ground-Water Hydrology of the Monongahela River Basin in West Virginia." OR 68-207

MD68-95 WATER QUALITY SURVEY IN THE NORTH BRANCH - POTOMAC RIVER BETWEEN CUMBERLAND AND LUKE, MARYLAND - AUGUST 1967

Chesapeake Field Sta., U.S. Dept. Int., Fed. Water Pollut. Contr. Admin., April 1968. 10 pp. Tables give date and time of sample, flow in cfs, BOD, DO, alkalinity, acidity, temperature, and field pH. Ten survey stations reporting are described and shown on a map of the study area. OR 68-206

MD68-96 WATER TREATMENT PLANT ATTRACTIVE AND EFFICIENT

Consol News 7 (4), 6-7 (1968). The water treatment plant at Consolidation Coal Company's Montour 4 Mine is described and pictured. The water is neutralized, aerated, and solids allowed to settle out. The clear water overflows into Chartiers Creek. Disposal of sludge is a problem as the treatment results in the equivalent of 14 carloads of sludge per day. This relatively low cost treatment plant was designed, built, and is operated by the Pittsburgh Coal Company Division. OR 68-176

MD68-97 THE EFFECTS OF STRIP MINING ON THE MICROBIOLOGY OF A STREAM FREE FROM DOMESTIC POLLUTION

Weaver, R. H. and Nash, H. D. (Univ. Ky.), Second Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa., 1968. pp 80-97. Cane Branch of Beaver Creek in McCreary County, Kentucky, draining an area that was surface mined between 1955 and 1959 has been compared to Helton Branch, draining an area where there has been no surface mining. Studies of the bacteria, fungi, and algae of the streams have shown the effects of distance from the sources of mining pollution, microenvironments in the streams, season of the year, and the quantity of stream flow. OR 68-8

MD68-98 FEASIBILITY STUDY ON THE APPLICATION OF VARIOUS GROUTING AGENTS, TECHNIQUES AND METHODS TO THE ABATEMENT OF MINE DRAINAGE POLLUTION. PART IV. ADDITIONAL LABORATORY AND FIELD TESTS FOR EVALUATING AND IMPROVING METHODS FOR ABATING MINE DRAINAGE POLLUTION

Wenzel, R. W., Halliburton Co., Draft Final Rept. to U.S. Dept. Int., FWPCA, Monongahela River Mine Drainage Remedial Project, 1968. 236 pp. In order to increase the success of mine sealing as a method of controlling pollution from mine drainage, studies were carried out on various types of plugs and on slurries used for grouting. Procedures are fully described and results are given in detail. Section 4 gives details of a seismic survey carried out to locate hidden mine openings and thin highwall sections. OR 68-156

MD68-99 STREAM POLLUTION CONTROL IN THE STEEL INDUSTRY

Young, E. F., Jr. and Jukkola, W. H. (Jones & Laughlin Steel Corp.), AIME Ann. Meet., New York City, Feb. 25-29, 1968. Preprint 68B38. 11 pp. One of the sources of stream pollution in the steel industry is mine drainage. As part of the general discussion, the authors describe and give a diagram of the abatement procedure that combines lime neutralization and controlled settling with underground disposal of sludge. OR 68-185

MD68-100 SULFIDE TREATMENT OF ACID MINE DRAINAGE

Zawadzki, E. A. and Glenn, R. A., Bituminous Coal Res., Inc., Final Rept. L-290, to Appalachian Regional Comm. and U.S. Dept. Int., FWPCA (1968). 94 pp. This approach to the treatment of mine drainage is based on removing iron as an insoluble sulfide. Of the various sulfides tested on samples of actual mine water, hydrogen sulfide, used after adjusting the pH to more than 6 with limestone, is considered most feasible. The sludge produced seems to be more compact and more easily filtered than sludge from limestone treatment. A system for regenerating hydrogen sulfide from the sludge is proposed but has not been developed. Comparative cost estimates are given for limestone treatment and for the conceptual limestone-hydrogen sulfide treatment. OR 68-195

1969

MD69-1 UPPER POTOMAC RIVER BASIN WATER QUALITY ASSESSMENT

Aalto, J. A., Clark, L. J., and Jaworski, N. A., U.S. Dept. Int., FWPCA, Chesapeake Tech. Support Lab., Tech. Rept. No. 17 (1969). 140 pp. The report presents detailed results of water sampling at a number of locations on the Upper Potomac River and its tributaries. While the main emphasis of the report is on the bacterial, pesticide, and nutrient loadings, the effects of mine drainage on the North Branch Potomac River are also noted. OR 69-105

MD69-2 ACID MINE DRAINAGE IN APPALACHIA

Appalachian Regional Comm., Rept. to President of the U.S., (1969). 126 pp. NTIS, PB-243 096/5WP. The causes, extent, and effects of acid mine drainage pollution in the area are reviewed. Twenty-four treatment and control methods are described. Costs are given for the 12 techniques which are considered practical. OR 69-77

MD69-3 ACID MINE DRAINAGE: PREVENTION, CONTROL, TREATMENT; CONTROL CASE HISTORIES

Coal Age 74 (7), 183-194 (1969). Lagooning, aeration, and neutralization with lime and limestone are discussed in some detail. The ORSANCO publication, "Principles and guide to practices in the control of acid mine-drainage" is reproduced, with additional case histories. OR 69-62

MD69-4 ACID MINE WATER + LIMESTONE = CLEAN STREAM

Coal Age 74 (2), 112-114 (1969). The acid effluent of the Lucerne 3A Mine of the Rochester & Pittsburgh Coal Company is mixed with finely ground limestone in a revolving drum and then discharged to a retention pond for sludge settling. The revolution of the treatment drum provides a grinding action of the limestone, exposing fresh surfaces for reaction with the mine drainage. Treatment increases pH from approximately 3 to more than 6. Average monthly values of pH and iron content in treated and untreated mine waters are compared. OR 69-3

MD69-5 HYDROLOGY AND CHEMISTRY OF COAL-MINE DRAINAGE IN INDIANA

Agnew, A. F. and Corbett, D. M. (Ind. Univ.), ACS Div. Fuel Chem. Preprints 13 (2), 137-149 (1969). The flush out effect in the Busseron Creek Watershed is described by using analyses of samples taken during one particular heavy rainfall. Problems in methods of analysis of mine waters and in correlating results are pointed out. OR 69-17

MD69-6 AUTOMATIC STATION TREATS CANTERBURY COAL'S DRAINAGE

Coal Mining Process. 6 (9), 42-43 (1969). Drainage with pH of 2 and 200 to 300 ppm iron from a worked-out portion of the mine is combined with water with pH 4 and 20 ppm iron collected from the active workings. The combined stream flows through an aeration channel to the holding pond on the upstream side of the treatment plant. Neutralization of the acid water is carried out with hydrated lime. A 45 foot static thickener aids in sludge handling. OR 69-100

MD69-7 STUDIES OF THE EFFECT OF GAS ATMOSPHERES ON PYRITE OXIDATION

Bell, W. E., Cyrus Wm. Rice & Co., Rept. to U.S. Dept. Int., FWPCA, April 1969. 58 pp. This report gives the experimental procedures and the results in detail. Effluents from pyrite in various nitrogen atmospheres contained greatly reduced amounts of acid, sulfate, and iron. OR 69-23

MD69-8 A STUDY OF INERT GAS ATMOSPHERES ON THE OXIDATION OF COAL MINE PYRITES

Bell, W. E. and Escher, E. D. (Cyrus Wm. Rice & Co.), ACS Div. Fuel Chem. Preprints 13 (2), 42-49 (1969). In this laboratory experiment, columns of crushed pyrite are exposed to demineralized water and to controlled atmospheres of air, nitrogen, and nitrogen/carbon dioxide. The daily analyses of the effluent for pH, total acidity, conductivity, and iron are plotted on detailed graphs for each column. Although the air-free atmosphere does not seem to stop oxidation of pyrite completely, it does markedly reduce the production of oxidation products. OR 69-6

MD69-9 ALGAE IN RELATION TO MINE WATER

Bennett, H. D., Castanea 34, 306-328 (1969). W. Va. Univ. Bull. Ser. 70 (6-2) (1969). Seventeen sampling stations in the Monongahela River Basin were chosen to represent a broad geographic area and four different habitat groups: pond, rivers, less acid creek, and acid creek. The bimonthly collections taken as far as possible during an annual cycle were analyzed to identify the organisms and to determine their general abundance. Water quality parameters determined for each station were pH, total acidity, phosphate, nitrate, iron, calcium, and oxygen. The variety and abundance of species depended on habitat and season of the year and on total acidity, pH and iron concentration. While a few algae were most abundant in mine water, many others found in mine water are common over a range of habitats. OR 69-70

MD69-10 AUGER MINE DRAINAGE STUDY

Berman, D. and Stratakis, N., Green Eng. Co., Rept. to Pa. Dept. Mines Miner. Ind., Coal Res. Board, CR-97 (1969). 74 pp. This study includes a field investigation of 23 mines and a comprehensive collection and analysis of drainage samples carried out from December 1968 through August 1969 to study seasonal effects. However, there was low precipitation during the winter and the season variation in flow was not as large as had been expected. All samples were analyzed for pH, alkalinity, acidity, total iron, and sulfate and the results are tabulated. Recommendations are made for restoring auger mined areas. Work on the development of an improved, economical, and easily installed plug for auger holes is also recommended. OR 69-43

MD69-11 IN-SITU TREATMENT OF SULFIDE MINERALS TO REDUCE ACID DRAINAGE

Bloom, D. N. (1), Jennings, L. D. (1), and Bisque, R. E. (2) [(1) Earth Sciences, Inc., (2) Colo. School Mines], AIChE Meet., Houston, Tex., Apr. 24-25, 1969. 5 pp. Mono-, di-, and tri-chloro derivatives of silane are evaluated for in-situ treatment of weathering sulfides. Among the advantages are that the compounds react readily in the gaseous state with mineral sulfides, making their surface hydrophobic; bonding is stable in acid media; and there is no toxicity related to treated sulfides. A disadvantage is that the gaseous silane derivatives react with water. Plans for field testing are outlined. OR 69-35

MD69-12 BLUE COAL'S WANAMIE NO. 19 WATER TREATMENT PLANT

Coal Mining Process. 6 (10), 56-58 (1969). The neutralization plant, located about 10 miles southwest of Wilkes-Barre, Pennsylvania, is designed to use lime, limestone, or pebble lime, added by adjustable feed. The discharge is sprayed to either of two settling ponds for aeration and precipitation. Overflow of the neutralized water goes to a nearby creek. OR 69-48

MD69-13 A REVIEW OF THE LITERATURE OF 1968 ON WASTEWATER AND WATER POLLUTION CONTROL: COAL AND COAL MINE DRAINAGE

Boyer, J. F., Jr. (Bituminous Coal Res., Inc.), J. Water Pollut. Contr. Fed. 41 (6), 1178-1186 (1969). The second annual review of the literature is based on abstracts included in the 1968 supplement to "Mine Drainage Abstracts--A Bibliography." Some of the subjects covered in the review are microbiological studies, chemistry of mine drainage, hydrology, treatment processes, iron removal, Pennsylvania's large

MD69-13 (continued)

and active abatement program, and Federal Water Pollution Control Administration sponsored projects. There are 81 references. OR 69-32

MD69-14 STATEMENT

Boyer, J. F., Jr. (Bituminous Coal Res., Inc.), Natl. Water Comm., Washington, D.C., Nov. 6, 1969. 18 pp. The mine drainage problem is reviewed with special emphasis on the need for accelerating the progress in developing abatement and control technology. OR 69-65

MD69-15 LOYALHANNA CREEK WATERSHED ENGINEERING SURVEY

Brant, J. W., Buchart-Horn Consulting Eng. Planners, Progr. Rept. to Pa. Dept. Mines Miner. Ind., Project No. SL-122, July 31, 1969. 30 pp. Water analyses and flow at seven sampling stations and two gaging stations of the Loyalhanna Creek from April through July 1969 are recorded. Sources of pollution on the main stream and on the tributaries are plotted on the schematic diagram of the watershed. Water pollution characteristics are found to be diluted by rainfall except for the Getty Run tributary area. OR 69-75

MD69-16 NEUTRALIZATION AND PRECOAT FILTRATION OF CONCENTRATED SLUDGE FROM ACID MINE WATER AT THE RUSHTON MINING COMPANY IN OSCEOLA MILLS, PA. PROJECT CR-82

Brown, T. S. and Long, B. W., Johns-Manville Prod. Corp., Res. Eng. Center, Rept. No. E412-8087-S1 to Pa. Coal Res. Bd., Nov. 3, 1969. 16 pp. Four filter aid grades were evaluated for their ability to dewater sludge produced by neutralization of mine water by limestone with magnesite. The filter aid showing the best characteristics of flow rate and usage was used to evaluate the filter ability of sludge from neutralization by limestone with lime and by lime with magnesite. The results were verified by 24 hour runs with neutralization by limestone-magnesite compared to neutralization by limestone alone. The costs given show limestone combined with CELITE 501 as a filter aid to be most economical. OR 69-74

MD69-17 WATER QUALITY AND AGING OF STRIP-MINE LAKES

Campbell, R. S. (1) and Lind, O. T. (2) [(1) Univ. Mo. and (2) Baylor Univ.], J. Water Pollut. Contr. Fed. 41 (11-Pt. 1), 1943-1955 (1969). A description of the aging process of surface-mine lakes is based on the comparison of five lakes studied intensively from 1962-67 and the changes in three of these lakes shown by studies in 1940-41 and in 1949-50. Heat budgets, ionic composition, and light properties are among the factors compared. In general, aging results in a decrease in potential acidity and in ionic content except that an increase in bicarbonate ion is associated with the alkaline stage. OR 69-46

MD69-18 CHRISTOPHER ATTACKS MINE-DRAINAGE PROBLEM

Coal Age 74 (9), 80-82 (1969). This article gives the details of the mine drainage treatment plant of the Christopher Coal Company at the Pursglove No. 15 mine on Dunkard Creek near Morgantown, West Virginia. Lime slurry is added to raw water which then goes to an aeration pond where iron is oxidized. The sludge remains in suspension until the water flows to the settling ponds. The raw water has a pH of 5.7 with about 600 ppm ferrous iron. Quality of treated water is pH 6.8 to 7.2, iron 1 to 8 ppm, and alkalinity 40 to 100. Sludge from the settling ponds is drained to a 30 million gallon holding lagoon. OR 69-85

MD69-19 CHRISTOPHER PLANT ATTACKS MINE DRAINAGE, SLUDGE PROBLEMS

Consol News 8 (1), 2-3 (1969). The lime slurry treatment plant, including aeration and settling ponds, at the Pursglove Mine near Morgantown, West Virginia, is

MD69-19 (continued)

described. Disposal of sludge remains the chief problem. OR 69-1

MD69-20 MINE DRAINAGE IN THE NORTH BRANCH POTOMAC RIVER BASIN

Clark, L. J., U.S. Dept. Int., FWPCA, Chesapeake Tech. Support Lab., Tech. Rept. No. 13 (1969). 80 pp. A stream sampling program was carried out from March 1968 through May 1969. Data were collected for 16 survey areas on flow, pH, conductivity, temperature, total alkalinity, total hot acidity, and sulfate. Elk Run in West Virginia is identified as the most critical stream in the entire basin. A comparison with earlier data indicates that the water quality above Luke, Maryland, has deteriorated since 1965. Detailed cost estimates for abatement measures are based on the maximum acidity loading for the seven watersheds considered. OR 69-87

MD69-21 INFLUENCE OF ACID MINE WATER ON THE MICROFLORA OF SEWAGE

Cook, H. A., Ph.D. Thesis, W. Va. Univ., 1969. 82 pp. The three-fold purpose of this work was to study the microflora of a mine acid polluted river, the Monongahela; to study the effects of acid mine water on the microorganisms in domestic sewage; and to determine if raw sewage contains amino acids which could serve as nutrients for the microflora in the receiving waters. Microbial population in samples from specified sites along the Monongahela River are reported as total number and percentages of bacteria, yeasts, and filamentous fungi. Temperature and pH influence the number and types of organisms present in incubated samples. Raw sewage alone and mixed with acid mine water were analyzed for amino acids. Several of the 17 amino acids detected in the sewage could not be detected in the mine water-sewage mixture and others were present in the mixture only in trace amounts. In the mixture, ammonia concentration increases greatly. OR 69-95

MD69-22 ACID MINE-DRAINAGE PROBLEM OF THE PATOKA RIVER WATERSHED, SOUTHWESTERN INDIANA

Corbett, D. M., Ind. Univ., Water Resour. Res. Cent., Rept. Invest. No. 4 (1969). 173 pp.+ Analyses of 436 water samples, taken at 100 sites during the 3-1/2 year study, and the flow rates at the sites are correlated with precipitation data and acid character of the flush out effect. Water quality is shown to be influenced more by mining debris and overburden having a high pyritic content than by exposed coal seams. A pumping project by Enos Mining Company in developing one of its coal fields in the area shows that overburden can act as a reservoir and help equalize river flow. The U.S. Public Health Service Mine-sealing Project in Southern Indiana in 1935-40 and available information about dams built in the area are reviewed. Methods recommended to reduce acid production are described. OR 69-40

MD69-23 EFFECTS OF STRIP-MINING ON THE HYDROLOGY OF SMALL MOUNTAIN WATERSHEDS IN APPALACHIA

Curtis, W. R. (Northeastern Forest Exp. Sta., Berea, Ky.), Intern. Symp. Ecology Revegetation of Drastically Disturbed Areas, University Park, Pa., by Pa. State Univ., 1969. 21 pp. Published in "Ecology and Reclamation of Devastated Land," Vol. 1, R. J. Hutnik and G. Davis, Eds., New York: Gordon and Breach, 1973. pp 145-157. Effects of surface-mining on hydrology as reported in the literature are summarized as background to continuing studies of Leatherwood Creek and Bear Branch in Breathitt County, Kentucky. Measurements of precipitation and stream flow by U.S. Geological Survey on Bear Creek recorded prior to the beginning of this study are augmented by information from weirs installed in three subdrainage areas of each watershed. Results of chemical and physical analyses made before, during and after mining were gathered for a two year period. It is noted that stream acidity did not change greatly, but that sulfate and magnesium increased. Sediment in the streams increased in all areas during active mining but sediment production was irregular when mining was not going on. OR 69-96

MD69-24 DEVELOPMENT OF BIOLOGICAL INDICES TO POLLUTION LEVELS IN STREAMS AFFECTED BY ACID MINE DRAINAGE AND OIL FIELD BRINE WASTES

Dambach, C. A. and Olive, J. H., Ohio State Univ., Natural Resour. Inst. and Water Resour. Cent., Res. Proj. Completion Rept. to U.S. Office Water Resour. Res. (1969). 90 pp. The upper Olentangy River and Whetstone Creek system in Southeastern Ohio contains organic pollution from sewage treatment plants and septic tank drainage, with chloride from oil field brines. Raccoon Creek, including the Sandy Run-Lake Hope tributary, shows acid mine drainage, but very little organic pollution. Analyses of samples taken over a two year period show that in the organic polluted streams, good correlation between the species diversity index and the chemical components of the water is not evident. Streams polluted with acid mine water show a low diversity of species, and small numbers of tolerant organisms, in spite of the fact that the waters were well oxygenated. Lake Hope showed a comparative abundance and diversity of organisms, confirming that a reservoir improves the physiocobiological conditions of an acid stream. There are 68 references. OR 69-60

MD69-25 LIMESTONE IN MINE DRAINAGE TREATMENT

Deul, M. (U.S. Bur. Mines), Mining Congr. J. 55 (11), 88-91 (1969). Controlling both the volume of water entering a mine and retention time of water in the mine results in smaller amounts of polluted water to be treated. Savings attributed to lower drainage volume are shown. OR 69-47

MD69-26 LIMESTONE IN MINE DRAINAGE TREATMENT

Deul, M. (U.S. Bur. Mines, Pittsburgh), "Report on Coal Technology - 1969," Vol. 1, Washington: American Mining Congress, 1969. 9 pp. Lime and limestone neutralization of mine drainage are discussed. Reducing the volume of drainage to be treated is suggested as a means of reducing treatment costs. OR 69-28

MD69-27 EFFECTS OF MINE DRAINAGE ON GROUND WATER

Emrich, G. H. (1) and Merritt, G. L. (2) [(1) Pa. Dept. Health and (2) W. Va. Univ.], Ground Water 7 (3), 27-32 (1969). The Toms Run area of Northwestern Pennsylvania illustrates the effect of coal mine drainage on ground water. Information on water quality is tabulated for various aquifers and for discharge from oil and gas wells and from mining. Ground waters near mining show low chloride, and lower pH and higher sulfate and iron than ground waters in nonmining areas, indicating the movement of acid mine drainage into aquifers and explaining the source of various iron-rich seeps and springs in the area. OR 69-56

MD69-28 ENGINEERING ECONOMIC STUDY OF MINE DRAINAGE CONTROL TECHNIQUES: APPENDIX B TO ACID MINE DRAINAGE IN APPALACHIA

Cyrus Wm. Rice and Co., Rept. to Appalachian Regional Comm. (1969). 281 pp. NTIS PB-243 098/1WN. Twenty-three mine drainage abatement techniques were reviewed and are categorized according to available cost information. No one method is outstanding in cost effectiveness, so each drainage basin should be studied separately to determine the method or combination of methods to use. OR 69-79

MD69-29 TREATMENT OF EARTH SURFACE AND SUBSURFACE FOR PREVENTION OF ACIDIC DRAINAGE FROM THE SOIL

Flynn, J. P. (to Dow Chemical Co.), U.S. Pat. 3,443,882 (May 13, 1969). 3 pp. Acid formation is prevented by mixing an inorganic phosphate with pyrite-type rock or soil thereby coating the sulfide mineral with a precipitate of ferrous phosphate. Chlorine or bromine either in gaseous form or as decomposition products are also recommended to supplement the chemical action of phosphates and prevent bacterial oxidation of pyrites. Examples are given of treating surface mine refuse and roof and floor of underground mines. OR 69-37

MD69-30 GAS REQUIREMENTS TO PRESSURIZE ABANDONED DEEP MINES

Cyrus Wm. Rice Co., Rept. to Pa. Dept. Mines Miner. Ind., Coal Res. Bd., and U.S. Dept. Int., FWPCA (1969). 89 pp. The use of inert gas as a mine atmosphere to prevent oxidation of pyrite was evaluated. Although some pressure could be maintained during barometric changes in the smaller of the two mines studied, leaks were found to be a problem of this technique. Maps and photographs of the mined area, descriptions of the equipment used, and details of the operation of the project are included in the report. OR 69-61

MD69-31 MINE WATER TREATMENT--FRICK DISTRICT

Godard, R. R. (U.S. Steel Corp.), "Report on Coal Technology - 1969," Vol. 1, Washington: American Mining Congress, 1969. 45 pp. The author reviews U.S. Steel's Frick Division's treatment of acid mine drainage from the neutralization plant built in 1913 when the division was H. C. Frick Coke Company through the modern facilities at Maple Creek, Karen, and Robena Mines. Early attempts at finding commercial uses for sludge are discussed. OR 69-29

MD69-32 NEUTRALIZATION AND AERATION OF ACID MINE WATERS (A LITERATURE SURVEY)

Harrison, V. F., Canada Dept. Energy, Mines Resour., Mines Br., Ottawa, IC 227 (1969). 41 pp. The neutralization of acid mine water by lime and by limestone is reviewed. There are 27 references. OR 69-90

MD69-33 ACID MINE WATER CONTROL

Hill, R. D. (U.S. Dept. Int., FWPCA, Cincinnati, Ohio), Univ. Mo., Mining Environ. Conf., Rolla, Mo., Apr. 16-18, 1969. 14 pp. This review of current research on acid mine drainage is divided into three categories. The latest knowledge of mine drainage chemistry is outlined under mechanisms of mine drainage chemistry. Under prevention of mine drainage formation are considered methods applicable to surface mines and to underground mines. Neutralization, biological treatment, reverse osmosis and neutralization-aeration are among the subjects discussed in the section on treatment of mine drainage. OR 69-22

MD69-34 THE EFFECTIVENESS OF MINE DRAINAGE POLLUTION CONTROL MEASURES, ELKINS, WEST VIRGINIA

Hill, R. D. (U.S. Dept. Int., FWPCA), ACS Div. Fuel Chem. Preprints 13 (2), 103-115 (1969). Air and water seals of deep mines, regrading, revegetation, and water diversion are the control methods used. During the first year following the completion of the reclamation, water quality showed some slight improvement. Preliminary data on costs for the various methods are given. OR 69-13

MD69-35 NEUTRALIZATION OF ACID MINE DRAINAGE

Hill, D. W. (U.S. Dept. Int., FWPCA, Athens, Ga.), J. Water Pollut. Contr. Fed. 41 (10), 1702-1715 (1969). The recycling of mine drainage sludge was evaluated in laboratory studies. When stock solution of ferric sulfate is adjusted to various pH values, sludge recycle is somewhat effective below pH 4. Above pH 4, rates of coagulation and settling are too fast for sludge recycle to make a noticeable difference. A two-step neutralization with removal of flocculant sludge at a pH of about 4 results in alkali savings when carried out on dilute ferric sulfate solutions, but not on more concentrated solutions, nor on an artificial acid mine drainage. Artificial dolomitic limestone is found to be less effective for neutralization than limewater or slaked lime. In recirculation of sludge in a two-step neutralization, the ratio of the neutralizing materials, slaked lime to artificial dolomitic limestone, seems to be a more important factor than the presence of sludge. OR 69-45

MD69-36 RECLAMATION AND REVEGETATION OF STRIP-MINED LANDS FOR POLLUTION AND EROSION CONTROL

Hill, R. D. (U.S. Dept. Int., FWPCA, Cincinnati, Ohio), Am. Soc. Agr. Engrs. Winter Meet., Chicago, Ill., 1969. Paper No. 69-705. 31 pp. Also "Reclamation and revegetation of 640 acres of surface mines - Elkins, West Virginia," Paper VII-6 in "Ecology and Reclamation of Devastated Land," Vol. 2, R. J. Hutnick and G. Davis, Eds., New York: Gordon and Breach 1973. pp 417-450. The case history of a reclamation project in Elkins, West Virginia, serves as an illustration of control of pollution from the acid drainage that can result from surface mining. Backfill and revegetation are discussed in detail. Pollution load of the streams in the watershed area before reclamation is compared with wastes carried after reclamation. Acidity is lower, but soil analyses show that sulfate remains in the soil to be leached out as future acid pollution. OR 69-52

MD69-37 EXPERIENCE IN OPERATING AN EXPERIMENTAL ACID MINE DRAINAGE TREATMENT PLANT

Holland, C. T. (W. Va. Univ.), ACS Div. Fuel Chem. Preprints 13 (2), 124-136 (1969). This paper is a continuation of the evaluation of the lime neutralization treatment plant reported previously. Waters from two more mines are treated separately and mixed. Results are given for quality of effluent, amount of sludge formed, and costs of operation. Problems with slurry-feed apparatus and aeration equipment are described. OR 69-16

MD69-38 SOME ASPECTS OF STREAM POLLUTION CONTROL FROM ACID MINE DRAINAGE

Holland, C. T. (W. Va. Univ.), Proc. W. Va. Coal Mining Inst., Bluefield and White Sulphur Springs, W. Va., 1968 (1969). pp 189-203. The author discusses corrective measures to prevent and control mine drainage. The disadvantages of lime neutralization are noted, particularly the resultant sludge that must be disposed of and the hardness of lime-treated waters. Tables give flow and pH of streams in the Monongahela watershed for 1961 and estimated costs of neutralizing mine waters of various acidity with hydrated lime. OR 69-50

MD69-39 THE IMPACTS OF MINE DRAINAGE POLLUTION ON LOCATION DECISIONS OF MANUFACTURING INDUSTRY IN APPALACHIA: APPENDIX D TO ACID MINE DRAINAGE IN APPALACHIA

The Fantus Co., Rept. to Appalachian Regional Comm. (1969). 304 pp. NTIS PB-243 100/5WN. Twenty case histories of plant location searches in which water supply was a factor are discussed. In each case, one of several locations considered was a mine drainage polluted area identified in the 1967 FWPCA publication, "Coal Mine Drainage in Appalachia." The most critical aspects of mine drainage for several types of industry are the amounts of iron and manganese in the water. In general, water was one of the less significant reasons for choice of location, particularly when unfavorable water conditions were compensated for by other favorable site factors. OR 69-81

MD69-40 THE INCIDENCE AND FORMATION OF MINE DRAINAGE POLLUTION: APPENDIX C TO ACID MINE DRAINAGE IN APPALACHIA

U.S. Army Corps Eng., U.S. Dept. Int., FWPCA, and Bur. Mines, Rept. to Appalachian Regional Comm. (1969). 411 pp. NTIS, PB-243 099/9WN. This appendix is also Volume 18 of "Development of Water Resources in Appalachia," U.S. Army Corps of Engineers Report of Office of Appalachia, prepared under authority of Appalachian Regional Development Act of 1965, Public Law 89-4. The report describes the extent and intensity of mine drainage pollution in Appalachia and discusses in detail the chemistry of mine drainage and mine drainage formation. A recommendation is made that pollution control should be considered whenever any flood control projects are planned in areas subject to mine drainage. OR 69-80

MD69-41 INVENTORY OF COAL MINE DRAINAGE SOURCES, SELECTED AREAS, UPPER OHIO RIVER BASIN

U.S. Dept. Int., FWPCA, Ohio Basin Region, Work Document No. 32 (1969). 110 pp. The tabulated information for 45 minor watersheds of the upper Ohio River Basin shows the type and number of acid pollution sources, total discharge, total net acidity, total hardness, sulfate, total iron, and manganese. Rivers and streams throughout the area are predominantly acid with most of the pollution coming from inactive mines and abandoned refuse areas. The survey identifies specific areas to be treated and gives information on which to base priorities. One abatement demonstration project is on the upper Tygart Valley River watershed where surface water is being diverted from stripped and mined areas and land is being reclaimed. OR 69-26

MD69-42 MINE ACID DRAINAGE AND ASSOCIATED FLOW FLUCTUATIONS

Jenkins, C. R. (1) and Carroll, H. C. (2) [(1) W. Va. Univ. and (2) N. Y. State Dept. Conserv.], Proc. W. Va. Acad. Sci. (1969). pp 286-293. This paper reports the amount and flow from the three major sources of mine drainage to the Left Fork of Little Sandy Creek in West Virginia. Acid production varied directly with flow. Sulfate, iron, and aluminum varied in much the same way. The pH was relatively constant and remained independent of flow. The acid load from seven mine effluents was shown to be the major source of acid in the receiving stream. OR 69-104

MD69-43 ABATEMENT OF POLLUTION FROM ABANDONED COAL MINES BY MEANS OF IN-SITU PRECIPITATION TECHNIQUES

Jones, J. B. and Ruggeri, S. (Parsons-Jurden Corp.), ACS Div. Fuel Chem. Preprints 13 (2), 116-119 (1969). In a planned demonstration project a slurry of limestone or fly ash will be added directly to acid water in a mine. Laboratory tests have indicated that sludge from the neutralization will fill and effectively seal the mine. OR 69-14

MD69-44 THE BIOLOGICAL AND ECOLOGICAL EFFECTS OF ACID MINE DRAINAGE WITH PARTICULAR EMPHASIS TO THE WATERS OF THE APPALACHIAN REGION: APPENDIX F TO ACID MINE DRAINAGE IN APPALACHIA

Katz, M. (Univ. Wash.), Rept. to Appalachian Regional Comm. (1969). 65 pp. NTIS, PB-243 101/3WN. (Bound with Appendix E). The effects of acid mine water on fish, aquatic invertebrates, plants, and terrestrial vertebrates are reviewed and discussed. Aquatic life is severly curtailed below pH 5. Above that point it becomes progressively more diverse and more stable as water becomes neutral. Since guidelines for water quality criteria for various uses have fairly uniform pH limits, abatement measures will improve acid waters for multiple uses. There are 224 references. OR 69-83

MD69-45 LAKE HOPE ACID MINE DRAINAGE ABATEMENT PROGRAM

Koehrsen, L. G., Stanley Consultants, Rept. to Ohio Dept. Natural Resour. (1969). 38 pp. Acid mine drainage has contaminated man-made Lake Hope to the extent that the pH of the water is in the range of 4.5 to 5.5 and sustains a meager fish population. Comparison with early reports indicates a drop in pH of the water of the lake over the years. A field study was carried out to verify sources of acid pollution. Results indicate that natural unpolluted stream flows are alkaline. Also evaluated are various pollution control techniques and their costs. Recommendations include pollution control techniques and a monitoring system. OR 69-31

MD69-46 SURVIVAL AND ACTIVITY OF SEWAGE MICROORGANISMS IN ACID MINE WATER

Kralovic, R. C. and Wilson, H. A., W. Va. Univ., Appalachian Center, Water Res. Inst., Res. Rept. 1 (1969). 30 pp. Samples of sewage and mine discharge were used to investigate the effect of acid mine drainage on the organisms which decompose

MD69-46 (continued)

organic wastes. The addition of strongly acid water resulted in an initial rapid decrease in sewage microorganisms. At about 4 C, the number of microorganisms continued to decrease. However, at 22 C and low pH the number of microorganisms increased after the initial reduction. The types of microorganisms predominating were related to pH. Above pH 4.5-5.0, there seemed to be more bacteria; between 3.5-4.5 there seemed to be more yeasts; and below pH 3.5 filamentous fungi seemed to predominate. OR 69-51

MD69-47 WATER IN KENTUCKY

Krieger, R. A., Cushman, R. V., and Thomas, N. O. (U.S. Geol. Surv.), Ky. Geol. Surv., Ser. X, Spec. Publ. 16 (1969). 51 pp. Water supply, water use, and water quality in Kentucky are discussed. It is pointed out that acid mine drainage is a serious problem in coal field areas. The bibliography includes publications of both the U.S. Geological Survey and the Kentucky Geological Survey. OR 69-97

MD69-48 LIMESTONE NEUTRALIZATION

Lamb, J. C., Public Works 100, 150, 152 (May 1969). Details are given of the limestone neutralization process described in Bureau of Mines, RI 7191, Mihok, E. A., Deul, M., Chamberlain, C. E., and Selmeczi, J. G., "Mine water research: the limestone neutralization process" (1968). OR 69-93

MD69-49 LITTLE SCRUBGRASS CREEK GOES FULL CYCLE

Coal Mining Process. 6 (3), 47 (1969). This article describes the final step in restoring Little Scrubgrass Creek. The surface mine which was generating acid has been reclaimed. The mine drainage neutralization plant will be left in place until pollution abatement is assured. OR 69-5

MD69-50 NEUTRALIZATION AND PRECOAT FILTRATION OF CONCENTRATED SLUDGE FROM MINE WATER AT THE READING ANTHRACITE CO. IN ST. CLAIR, PA. PROJECT CR-82

Long, B. W., Johns-Manville Prod. Corp., Res. Eng. Center, Rept. No. E412-8087 to Pa. Coal Res. Bd., Sept. 15, 1969. 12 pp. This project evaluates filter aids used in dewatering sludge by a rotary vacuum precoat filtration method. Since the sludge was formed from limestone neutralization of acid mine drainage with about 23 mg/l of iron, the problem was to produce enough sludge for the filter tests. The equipment and results are described and costs are given for filter equipment and limestone consumption. OR 69-73

MD69-51 FLY ASH DISPOSAL IN A DEEP MINE

Love, L. R. and Whirl, S. F. (Duquesne Light Co.), Coal Mining Process. 6 (3), 50-53 (1969). Fly ash disposal in an abandoned section of a deep mine neutralized acid mine water. For 18 months, the discharge averaged over 2 million gallons per day and was within the limits of water quality specified by the Pennsylvania Sanitary Water Board. OR 69-99

MD69-52 BIOCHEMICAL ECOLOGY OF METAL SULFIDE OXIDIZING BACTERIA

Lundgren, D. G. and Tabita, F. R. (Biological Res. Lab., Syracuse Univ.), ACS Div. Fuel Chem. Preprints 13 (2), 60-67 (1969). Iron oxidation, sulfur oxidation and glucose oxidation by Ferrobacillus ferrooxidans are compared. Evaluation by electron microscope of the bacteria grown on different substrates shows differences in structure. However, the main emphasis of the paper is to show that the metabolic diversity of the organisms means that attempts to control them must consider their whole metabolic potential. OR 69-8

MD69-53 WATER QUALITY AND DISCHARGE OF STREAMS IN THE LEHIGH RIVER BASIN, PENNSYLVANIA

McCarren, E. F. and Keighton, W. B., U.S. Geol. Surv., Water-Supply Paper 1879-H (1969). 48 pp. The quality of water in the Lehigh River varies over its length, and is influenced by acid mine drainage and alkaline drainage from limestone formations. Water quality data collected systematically from 1944 through 1967 are summarized and include sampling date and values, as available, for mean discharge, silica, aluminum, iron, manganese, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, nitrate, dissolved solids, hardness, total acidity, specific conductance, pH, and color. OR 69-88

MD69-54 MINE WATER RESEARCH: CATALYTIC OXIDATION OF FERROUS IRON IN ACID MINE WATER BY ACTIVATED CARBON

Mihok, E. A., U.S. Bur. Mines, RI 7337 (1969). 7 pp. Laboratory batch flow tests carried out on acid mine water with high ferrous iron content show that preacidified activated carbon can significantly oxidize ferrous to ferric iron. In the single run without aeration, the ferrous iron oxidation was as effective as in other runs. The analyses of the feed and the effluent are tabulated along with flow and aspiration rates for each of the 65 tests. OR 69-44

MD69-55 MINE DRAINAGE POLLUTION AND RECREATION IN APPALACHIA: APPENDIX E TO ACID MINE DRAINAGE IN APPALACHIA

Robert R. Nathan Assoc., Inc., Rept. to Appalachian Regional Comm. (1969). 114 pp. NTIS,PB-243 101/3WN. The economic impact of recreation areas now in use and surveys of differentiated use of water-based facilities are the basis for projection to 1980 of the need for more recreation facilities. Whether mine drainage abatement is necessary depends on whether facilities presently in use become polluted (not considered likely); whether nonpolluted facilities can be developed to meet increased demands; and how tolerant the public is to effects of mine drainage pollution. OR 69-82

MD69-56 YOUGHIOGHENY RIVER BASIN MINE DRAINAGE POLLUTION ABATEMENT PROJECT

Moore, T. L. and Turcotte, J. A., Gibbs & Hill, Inc., Rept. of Phase 1, to Pa. Dept. Mines Miner. Ind. (1969). (100 pp.) This detailed report contains basic information about the Youghiogheny watershed necessary for the development of a mine drainage abatement program. Included in the description of the basin are the tributaries in the system, the topology and geology, water use, rainfall, and stream quality. Also included as a part of this report are three maps showing the 1,412 mines in the area. OR 69-21

MD69-57 OXYGENATION OF IRON(II) IN CONTINUOUS REACTIONS

O'Melia, C. R. (Dept. Environ. Sci. Eng.), Univ. N. C., Water Resour. Res. Inst., Rept. No. 23 (1969). 53 pp. The use of thermodynamics and kinetics of ferrous iron oxidation illustrates the development of an optimal design for a continuous treatment process to remove iron from natural waters. Experimental work carried out to test the design gave oxidation efficiencies considerably lower than was predicted. Increasing the temperature at which the reaction was carried out gave more nearly theoretical results. OR 69-68

MD69-58 ORSANCO 1969: 21ST YEARBOOK

Ohio River Valley Water Sanitation Comm., Cincinnati, Ohio, 1969. 28 pp. The results of the continuing water quality monitoring in the Ohio River and its tributaries are included in this annual report. OR 69-94

MD69-59 THE COAL MINE DRAINAGE PROBLEM IN NORTHERN WEST VIRGINIA

Pash, E. A. (U.S. Dept. Int., FWPCA, Wheeling, W. Va.), Soil Conserv. Soc. Am., W. Va. Chapter, Ann. Meet., Jacksons Mill, W. Va., 1969. 11 pp. Measurements of lengths of degraded streams, sources of pollution, and pollution load are given for the major tributaries of the Monongahela River in West Virginia. The information is based on the files and current studies of the Monongahela River Mine Drainage Remedial Project. OR 69-57

MD69-60 POLLUTION CAUSED FISH KILLS--1968

U.S. Dept. Int., FWPCA, CWA-7 (1969). 17 pp. Pollution from mining is given as one of the causes of fish kills in this listing of reports of fish kill incidents. OR 69-41

MD69-61 CONTROL OF POLLUTION FROM COAL MINE REFUSE SITES AND SLURRY PONDS

Ramsey, J. P. (Truax-Traer Coal Co.), AIME Fall Meet., Salt Lake City, Utah, Sept. 17-19, 1969. Preprint No. 69F330. 4 pp. The demonstration project near Du Quoin, Illinois, where a refuse site and slurry lagoon will provide basic data on the mine drainage abatement, is described. OR 69-114

MD69-62 THE RAUSCH CREEK WATERSHED TREATMENT PLANT

Anthracite Res. Develop. Co. Inc., Preliminary Design Rept., Project No. SL-112, for Pa. Dept. Mines Miner. Ind. (1969). 10 pp. After study, lime neutralization was recommended for Rausch Creek water. Pebble lime was recommended as most suitable for handling. The design calculations, a plot plan of the treatment plant and an estimate of project cost and the operating and maintenance expense are given. The 10 mgd capacity of the plant was based on flow records of the creek over a one year period. Any excess flow will be passed directly to the polishing lagoon with addition of sodium hydroxide for neutralization. OR 69-76

MD69-63 LIME SLURRY SYSTEM AT PURSGLOVE NO. 15 MINE

Ream, V. H. (Christopher Coal Co. Div., Consolidation Coal Co.), "Report on Coal Technology - 1969," Vol. 2, Washington: American Mining Congress, 1969. 9 pp. This discussion emphasizes the problems of continuously treating a large volume of water in a confined area. Several experiences with sludge handling are described. OR 69-30

MD69-64 ALLEGHENY RESERVOIR'S ROLE IN WATER QUALITY

Reilly, T. L. (Corps Eng., Pittsburgh, Pa.), J. Am. Water Works Assoc. 61 (5), 261-266 (1969). The initial experiences of coordinating the flows from the Kinzua Dam and the other flood control dams in the Allegheny River Basin to maintain water quality in the lower Allegheny River are reviewed. OR 69-106

MD69-65 MINE WATER BARRIER

Reinhold, R. H. (to Layne-New York Co., Inc.), U.S. Pat. 3,469,405 (Sept. 30, 1969). 4 pp. Seals are constructed in the mine using two parallel barriers of aggregate. The space between the barriers is grouted and filled through bore holes, giving a solid water-tight seal. OR 69-58

MD69-66 REPORT ON FEASIBILITY OF MINE WASTE POLLUTION ABATEMENT

Crawford, Murphy & Tilly, Inc., Rept. to Macoupin County, Ill. Bd. Supervisors, 1969. 37 pp. The main source of pollution on the Cahokia Creek watershed is acid drainage and erosion from refuse piles. The location and the ownership of the mine refuse piles are tabulated and shown on maps. Laboratory analyses of drainages from these piles are summarized. The proposed abatement project includes

MD69-66 (continued)

determining whether a nearby worked out mine is flooded and can be used to receive runoff diverted from the refuse pile; grading the pile; and, depending on the feasibility of the first phase, either constructing a holding pond with a borehole spillway or covering the pile in some manner. OR 69-59

MD69-67 REVERSE OSMOSIS FIELD TESTING ON ACID MINE WATERS AT NORTON, WEST VIRGINIA

Riedinger, A. B., Gulf General Atomic, Inc., Final Rept. to U.S. Dept. Int., Office Saline Water, Jan. 17, 1969. 21 pp. The equipment consisted of 18 modules in 6 pressure vessels, giving 900 square feet of membrane. The system was modified during the operation to allow recycling of the brine in order to increase the recovery. The performance of the unit at 600 psi, over a total operating time of more than 1600 hours, is given in two detailed tables. Although there is some variation in product flow, the overall conclusion is that a reverse osmosis unit can be operated satisfactorily on acid mine waters at 600 or 800 psi. OR 69-4

MD69-68 EVALUATION OF COMMON ALKALIES IN NEUTRALIZING ACID MINE WATER

Sanmarful, I. de C., M.S. Thesis, The Pa. State Univ., 1969. 42 pp. The characteristics and settling rates of sludges resulting from neutralization of mine water by calcium carbonate, calcium hydroxide, sodium hydroxide, and sodium carbonate were studied. Synthetic mine water was neutralized in a transparent plastic cylinder, and sludge settling rate was timed by visual monitoring of sludge-liquid interface and by determining solids content at various levels of the column. Carbonates sludges were granular and settled more rapidly. The hydroxides produced sludges that were more flocculant and voluminous. Choice of neutralizing agent for a particular mine drainage would depend on availability, cost, sludge handling method to be used, reaction time that can be accommodated, and disposal of the effluent. OR 69-98

MD69-69 OXIDATION KINETICS OF PYRITIC MATERIALS IN AQUEOUS MEDIA

Sasmojo, S., Ph.D. Thesis, Ohio State Univ., 1969. 182 pp. A critical discussion of previous studies of oxidation of pyritic materials introduces these studies which were carried out to clarify the oxidation mechanism in the formation of acid mine drainage. Most of the work was performed under anaerobic conditions where the ferric ion was the oxidant. The influence of pH, ferric-to-ferrous concentration ratio, total iron concentration, and the effect of sulfate ion on the reaction rate were investigated. Here the reaction rate can be explained in terms of heterogeneous reaction kinetics. Two runs made in the presence of oxygen on pyrite samples similar to those used in the anaerobic studies show that a direct reaction takes place between the pyrite surface and oxygen. The bibliography contains 58 references. OR 69-39

MD69-70 TREATMENT OF WATER

Selmeczi, J. C. (to Ionics, Incorporated), U.S. Pat. 3,420,773 (Jan. 7, 1969). 3 pp. Method for removing anions from water by providing a body of weakly basic anion exchange resin in substantially its free base form, introducing carbon dioxide into a stream of water to be purified, passing the water through the resin with removal of the anions and regulating the carbon dioxide flow into the stream to control the removal of anions from the water, the anions being removed in order of decreasing exchange potential. Additionally, ferrous salts will precipitate out as ferrous carbonate. (Abstract of the Disclosure) OR 69-115

MD69-71 EFFECT OF ANTIBACTERIAL AGENTS ON MINE DRAINAGES. USE OF VIABLE ANTIBACTERIAL AGENTS TO REDUCE POLLUTION BY MINE DRAINAGES

Shearer, R. E. and Everson, W. A., MSA Res. Corp., Rept. to U.S. Dept. Int., FWPCA,

MD69-71 (continued)

Water Pollut. Contr. Res. Ser., 14010EGJ 11/69 (1969). 138 pp. NTIS, PB-191 215. Some strains of caulobacter and certain Streptomyces species were found to inhibit the action of iron bacteria in mine drainages. The experimental apparatus simulating mine drainage conditions is described and detailed results of chemical and bacteriological testing are given. OR 69-67

MD69-72 A MODEL FOR PYRITIC SYSTEMS

Shumate, K. S. (1), Smith, E. E. (1), and Brant, R. A. (2) [(1) Ohio State Univ., (2) ORSANCO], ACS Div. Fuel Chem. Preprints 13 (2), 50-58 (1969). The authors present a means of describing pyritic systems and considering kinetics of oxidation reactions as a basis for intensive and critical discussion of the mine drainage problem. In their words, "The model is intended to identify and provide a framework for integration of the numerous factors which determine the rate of acid release from any type of pyritic system associated with mining activity." OR 69-7

MD69-73 OXYGENATION OF FERROUS IRON: THE RATE-DETERMINING STEP IN THE FORMATION OF ACIDIC MINE DRAINAGE

Singer, P. C. and Stumm, W., Harvard Univ., Final Rept. to U.S. Dept. Int., FWPCA, Water Pollut. Contr. Res. Ser., 14010---06/69 (1969). 216 pp. NTIS, PB-189 233. This study of the chemistry of aqueous iron considers models describing pyrite oxidation in order to increase the understanding of acid mine drainage. The solubility of ferrous iron and the effects of sulfate and pH are also discussed. Experimental data on ferrous iron oxidation lead to the conclusion that oxidation occurs more rapidly in natural mine water because of microbial catalysis. The feasibility of various methods of preventing mine drainage formation is examined. OR 69-64

MD69-74 THE RATE-DETERMINING STEP IN THE PRODUCTION OF ACIDIC MINE WASTES

Singer, P. C. and Stumm, W. (Harvard Univ.), ACS Div. Fuel Chem. Preprints 13 (2), 80-87 (1969). A model of the oxidation of iron pyrite in natural mine waters is proposed as the result of this laboratory and field study. The model consists of release of ferrous iron by simple dissociation or by oxidation of the pyrite by oxygen and a slow oxygenation of ferrous iron. Then a cycle is established in which ferric iron rapidly oxidizes pyrite and is slowly regenerated through oxidation of the resulting ferrous iron. Precipitated ferric hydroxide in the mine is considered to be a reservoir for soluble ferric iron so that a significant supply is readily available as an oxidant of pyrite. It is concluded that abatement of acid mine drainage pollution appears to be dependent on the control of the oxidation of ferrous iron. OR 69-10

MD69-75 AEROBIC-ANAEROBIC OXIDATION OF PYRITE

Smith, E. E., Svanks, K., and Halko, E. (Ohio State Univ.), ACS Div. Fuel Chem. Preprints 13 (2), 68-78 (1969). This study of kinetics and mechanism of pyrite oxidation compared reaction rates in a chemical system and in a biological system. The ferric/ferrous ratio and the total iron in solution determine the anaerobic oxidation rate of pyrite, while the oxygen concentration at the reaction site controls aerobic oxidation rate. The independence of the reactions of the two systems is shown by results of combined aerobic and anaerobic oxidation runs. OR 69-9

MD69-76 STATES MAKE HEADWAY ON MINE DRAINAGE

Environ. Sci. Technol. 3 (12), 1237-1239 (1969). The general problem of mine drainage is discussed. Pennsylvania's program for dealing with this type of water pollution is emphasized. OR 69-86

MD69-77 THE OXYGENATION OF IRON(II) SOLUTIONS: RELATIONSHIPS TO COAL MINE DRAINAGE TREATMENT

Stauffer, T. E. and Lovell, H. L. (Pa. State Univ.), ACS Div. Fuel Chem. Preprints 13 (2), 88-94 (1969). The effects of the variations of pH, temperature, iron concentration, and aluminum concentration on the rate of oxidation of ferrous iron are determined in this laboratory study. Each parameter is found to develop changes in the reaction rate. Of particular note are the major increase in rate occurring from the change in pH from 5.1 to 5.35 and the modification of the oxidation rate in the presence of aluminum ions. OR 69-11

MD69-78 SUBSURFACE DISPOSAL OF MINE WATER

Stefanko, R. (Pa. State Univ.), AIME Preprint No. 69-AIME-10 (1969). 16 pp.+ ACS Div. Fuel Chem. Preprints 13 (2), 95-102 (1969). The development of a deep well for disposal of water from No. 58 Mine of Bethlehem Mines Corporation is described in detail, from the geologic factors determining the location of the well, boring, testing of the cores, and the fresh water injection tests. The work was abandoned before mine water was introduced since the injection tests showed that much higher pumping pressures would be required than had been anticipated. OR 69-2

MD69-79 STREAM POLLUTION BY COAL MINE DRAINAGE IN APPALACHIA

U.S. Dept. Int., FWPCA, Cincinnati, Ohio (1969). 270 pp. This is a revision of the status report with the same title published in 1967. Information from the completed watershed studies has been included and discussions of costs have been omitted. OR 69-38

MD69-80 SULFIDE TREATMENT OF ACID MINE DRAINAGE

Bitum. Coal Res., Inc., Rept. to U.S. Dept. Int., FWPCA, Water Pollut. Contr. Ser., 14010DLC 11/69 (1969). 65 pp. NTIS, PB-187 866. This report describes the use of hydrogen sulfide with pulverized limestone to remove ferrous iron from mine waters. Careful control of hydrogen sulfide feed is needed to keep it out of the treated effluent. Ferric iron interferes in the process possibly forming elemental sulfur which may form polysulfides. This condition requires more reactant to precipitate the ferrous sulfide. OR 69-54

MD69-81 HYDROGEOLOGIC CONSIDERATIONS FOR SEALING COAL MINES

Thompson, D. R. and Emrich, G. H., Pa. Dept. of Health, Bur. Sanit. Eng., Publ. No. 23, August 1969. 21 pp. The report illustrates the various factors of geology, ground water, and mining development that must be considered for effective mine seals. OR 69-108

MD69-82 STAINLESS STEEL CULVERTS CUT MINE ACID DRAINAGE COST

Thrope, J. S. (Allegheny Ludlum Steel Corp.), Coal Age 74 (5), 104-106, 113 (1969). Photographs give visual evidence of the durability of stainless steel culverts which carry acid mine water. Laboratory tests, as well as field service tests, showing the successful use of stainless steel are described. OR 69-25

MD69-83 MICROBIAL DISSIMILATORY SULFUR CYCLE IN ACID MINE WATER

Tuttle, J. H., Dugan, P. R., MacMillan, C. B., and Randles, C. I. (Ohio State Univ.), J. Bacteriol. 97 (2), 594-602 (1969). The microbiological activity in a particular stream contaminated with acid mine drainage is described. The stream flows through a wood dust pile situated so that there is a pond on each side of it. Results of analyses of water from sampling stations both upstream and downstream of the pile are given. The data indicate that microbial action on the wood dust provides nutrients for sulfate reducing bacteria. One observation was that mixed cultures containing sulfate reducing bacteria were active at pH 3.0 in the laboratory with

MD69-83 (continued)

sawdust as the only nutrient while pure cultures of sulfate reducing bacteria isolated from the mixed cultures did not reduce sulfate below pH 5.5. OR 69-18

MD69-84 MICROBIAL SULFATE REDUCTION AND ITS POTENTIAL UTILITY AS AN ACID MINE WATER POLLUTION ABATEMENT PROCEDURE

Tuttle, J. H., Dugan, P. R., and Randles, C. I. (Ohio State Univ.), Appl. Microbiol. 17 (2), 297-302 (1969). Mine water with an added source of carbon can be treated by anaerobic sulfate reducing bacteria with resulting increase in pH and reduction of sulfate to sulfide. The action of mixed cultures of bacteria on variously prepared media at controlled temperatures is compared to see if the process can be accelerated. Wood dust and other organic chemicals are used as a source of carbon. Combining acid mine drainage with sewage, waste paper, or waste vegetable material for abatement of water pollution is suggested. OR 69-19

MD69-85 U.S. STEEL SOLVES ACID-WATER PROBLEMS

Coal Age 74 (5), 64-68 (1969). Treatment plants at three mines in U.S. Steel's Frick District are described and diagramed. At the Karen Mine, the effluent was neutralized with lime and treated with flocculant. The sludge was settled and then pumped into a mined out area. Operation of the plant ended in January, 1969, since the coal was depleted. Water at the Maple Creek Mine is alkaline so that aeration and settling to remove iron are all the treatment needed. Provision has been made for lime neutralization equipment to be added ahead of the aerator if the drainage ever becomes acid. The alkaline effluent from newer areas of the Robena Mine will be used to help neutralize acid water from older areas. OR 69-24

MD69-86 AUTOMATIC MINE DRAINAGE TREATMENT AT THE HANLEY COMPANY'S SUMMERVILLE BRICK PLANT

Uhler, K. A. (Yost Assoc., Inc., Du Bois, Pa.), Feb. 1969. 12 pp. Acid drainage from the mining of a clay seam adjacent to Clarion seam coal carries heavy loads of suspended clay. Based on results of laboratory studies, a treatment method combining lime neutralization and use of commercial flocculant aid was developed. The process treatment system described in detail included lime slurry feeders, aerators, coagulent aid feeders, and a clarifier. Sludge is pumped to an abandoned section of the mine. OR 69-110

MD69-87 VENTILATION AND DRAINAGE--PUMPING AND DRAINAGE

Coal Age 74 (10), 148-149 (1969). The lime treatment system for the 700,000 gpd drainage from Eastern Associated Coal Corporation's mine in Delmont, Pennsylvania, will be all underground in a large worked out section of the mine. Treated water is discharged to a settling lagoon from which clear water is pumped 356 feet to a surface discharge weir. It is estimated that the capacity of the settling lagoon will be enough for the sludge produced during the life of the mine. OR 69-49

MD69-88 ABATEMENT PROCEDURES RELATED TO ACID MINE DRAINAGE

Wayman, C. H. (Colo. School Mines), AIChE, Proc. Ind. Water Design for Water Pollut. Contr., Vol. 2, pp 38-44 (1969). Presented, AIChE Meet., Houston, Tex., Apr. 24-25, 1969. 19 pp. The present knowledge about acid mine drainage formation is discussed and is related to pollution abatement and control methods that are either in use or under consideration. OR 69-107, OR 69-36

MD69-89 THE MICROBIOLOGICAL OXIDATION OF FERROUS IRON IN MINE DRAINAGE WATER

Whitesell, L. B., Jr., Huddleston, R. L., and Allred, R. C. (Continental Oil Co.), ACS Div. Fuel Chem., 157th Natl. Meeting, Minneapolis, Minn., Apr. 13-18, 1969. 19 pp. The treatment of mine drainage with bacteria capable of oxidizing ferrous to

MD69-89 (continued)

ferric iron at very low pH is investigated. The studies include a comparison of cultures of bacteria from mine outfalls with cultures from laboratories in regard to nitrogen and phosphorus requirement, the effect of varying the concentration of ferrous ion, as well as the effects of temperature, pH, aeration, and CO_2 enrichment. OR 69-20

MD69-90 SAW MILL RUN, ALLEGHENY COUNTY, PENNSYLVANIA, REPORT ON SOURCES OF ACID MINE DRAINAGE

Whitfield, E. J. and Zabban, W., Chester Engineers, Inc., Rept. to Pa. Dept. Mines Miner. Ind. (1969). 33 pp. Four sources of acid mine drainage on Saw Mill Run watershed are identified. Values for pH, acidity, alkalinity, solids, calcium, magnesium, aluminum, iron, and sulfate are reported. The proposed treatment plant is designed to handle the major pollutants, sewage and trash, as well as to neutralize the acid drainage with caustic soda. OR 69-33

MD69-91 THE IMPACT OF MINE-DRAINAGE POLLUTION ON INDUSTRIAL WATER USERS IN APPALACHIA: APPENDIX A TO ACID MINE DRAINAGE IN APPALACHIA

Whitman, I. L. Nehman, G. I., and Qasim, S. R., Battelle Memorial Inst., Final Rept. to Appalachian Regional Comm. (1969). 253 pp. NTIS, PB-243 097/3WN. Surveys of water use and water quality requirements of a number of industries and of 22 Appalachian power plants, focused on the cost of water used compared to an estimate of savings from abatement of mine drainage pollution. General conclusions are that the greatest savings are from pollution reduction at the source rather than from lime treatment of acid water and that savings accrue most to those industries using the largest amounts of water and obtaining it directly from rivers. However, since the cost of adjusting to acid water supplies is an extremely low percentage of industrial costs, it is also concluded that mine drainage abatement would have little effect on the economy of the region. OR 69-78

MD69-92 EFFECT OF AN ACID-WATER ENVIRONMENT UPON THE SYNTHESIS OF GROWTH FACTORS (VITAMINS) BY BACTERIA

Wilson, H. A. and Richardson, K. L., Jr., W. Va. Univ., Water Res. Inst., Inform. Rept. 1 (1969). 6 pp. Three bacterial isolates from Monongahela River water and two from untreated domestic sewage are used to find whether the acid environment interferes with synthesis of growth factors, vitamins, or other substances. The particular isolates were all self-sufficient and showed growth below pH 4. At 0.2 pH below the previously determined minimum pH for growth, various additions of vitamins, fatty acids, soil extract, sterilized domestic sewage, and several sources of organic nitrogen were made to cultures of each organism. The only additive that encouraged growth of all organisms was a vitamin enriched casein hydrolysate. OR 69-84

MD69-93 WYOMING VALLEY MINE DRAINAGE POLLUTION ABATEMENT PROJECT

Pa. Dept. Health, Bur. Sanit. Eng., Div. Mine Drainage, Publ. No. 25 (undated). 27 pp. Since discharge from the underground water pools in the Wyoming Valley do not meet water quality standards, the Department of Mines and Mineral Industries has proposed three alternate plans to treat the discharge before it enters the Lackawanna and North Branch of the Susquehanna Rivers. The recommended plan provides two treatment plants, one for the Delaware discharge and one for the combined South Wilkes-Barre and Buttonwood discharges. Cost estimates are included. Also recommended is possible surface reclamation which could help reduce drainage volume and thereby lower treatment costs. OR 69-89

MD69-94 DESIGN OF LIMESTONE BARRIERS IN ACID MINE WATER STREAMS

Yen, A. F.-I., M.S. Thesis, Pa. State Univ., Sept. 1969. 49 pp. The conclusion of

MD69-94 (continued)

this laboratory study is that the six significant parameters in design of a limestone barrier for reduction of stream acidity are: stone size, flow rate, barrier length, superficial velocity, retention time, and the initial acidity. OR 69-111

1970

MD70-1 ABATEMENT OF POLLUTION FROM ABANDONED MINES IN PENNSYLVANIA: A PROGRESS REPORT

Pa. Dept. Health, Sanit. Water Bd., Publ. No. 26 (Mar. 1, 1970). 33 pp. Pollution abatement projects being carried out on Pennsylvania waters are listed by watersheds. Maps show representative streams affected. Abatement programs consist of Phase I "Pollution source inventory," Phase II "Engineering studies," Phase III "Construction," Phase IV "Operation and maintenance." The status of projects is given by bar graphs showing phase completion. Cost estimates are also reported. Publications resulting from abatement projects are listed. OR 70-41

MD70-2 ACID MINE DRAINAGE SURVEY - EAST BRANCH CLARION RIVER WATERSHED ELK AND MCKEAN COUNTIES

Michael Baker, Jr., Inc., Rept. to Pa. Dept. Mines Miner. Ind., Proj. No. SL-108 (1970). 379 pp. The survey of the East Branch Clarion River Watershed was carried out to determine the water quality of the main stem and its tributaries and to identify the sources and loadings of mine drainage pollution. Information on the main stem, the sub-basins of polluted tributaries, and unpolluted streams includes a general description of the area, identification of sources of pollution, summaries of water quality data, comparison with previous water quality, and recommendations for pollution abatement. Water samples were analyzed for pH, total acidity, free acidity, total alkalinity, total iron, and sulfate. Selected samples were analyzed for ferrous iron, manganese, aluminum, arsenic, calcium, and magnesium. Cost estimates of recommended abatement methods are also presented. OR 70-113

MD70-3 A HYDROLOGICAL APPROACH TO CONTROL ACID MINE POLLUTION FOR LAKE HOPE

Ahmad, M. U. (Ohio Univ.), Ground Water 8 (6), 19-24 (1970). The geology of the Todd and McDaniel mining areas near Lake Hope, Ohio, shows that there are three aquifers separated by impervious layers. The proposal is made to decrease acid drainage to the Lake Hope watershed by constructing weeping wells to convey water from the mines to aquifers below them. OR 70-78

MD70-4 STRIP MINING - PROBLEMS AND SOLUTION

Ahmad, M. U. (Ohio Univ.), Proc. Conf. New Approaches to Strip Mining - The Planning Concept, Lexington, Ky., by SCOPE and Environ. Awareness Soc., 1970. pp 80-86. The author describes the chemical cause of acid mine drainage and discusses the problem of silt from surface mining. Work in progress to map acid producing areas by means of thermal differences is also reported. OR 70-107

MD70-5 ALDER RUN WATERSHED MINE DRAINAGE STUDY

Skelly & Loy, Engineers, Consultants, Rept. to Pa. Dept. Mines Miner. Ind., Proj. No. SL-143 (1970). 108 pp. The survey of this tributary of the West Branch of the Susquehanna River identified as pollution sources deep mines, unrestored surface mine areas, and mining spoils. Effluent from deep mines in many cases had been increased by water diverted by surface mining. Water quality taken at 56 sampling sites is reported for July 1969 through May 1970. Information was compiled monthly on weather, flow, pH, acidity, alkalinity, total iron, sulfate, and, for May 1970, aluminum. Descriptions of each pollution source, abatement measures recommended for it, and the cost of carrying out the recommendations are tabulated. Results of a test boring program carried out to determine feasibility of mine sealing are presented. OR 70-72

MD70-6 EVALUATION OF CAULOBACTER AS AN INHIBITOR OF ACID MINE DRAINAGE FORMATION

Baker, R. A. and Wilshire, A. G. (Carnegie-Mellon Univ.), Rept. to U.S. Dept. Interior, FWQA, Res. Grant 14010 DKN (July 1970). 13 pp. A pilot plant study, and a critique of a previous investigation, showed that the caulobacter had no effect on the rates of acid mine drainage production. OR 70-54

MD70-7 EVALUATION OF POTENTIAL ACID MINE DRAINAGE

Baker, R. A. and Wilshire, A. G. (Carnegie-Mellon Univ.), Water Sewage Works *117* (6), IW/10-16 (1970). Four vertical packed-bed pilot plant reactors were operated to show how core samples could be tested to find the acid forming potential of a proposed mining site. Feed water of known composition flowed through the reactors under controlled conditions. Two reactors were aerated and two, non-aerated. One of each pair was seeded with equal amounts of *Ferrobacillus ferrooxidans*. *Ferrobacillus sulfooxidans*, and *Thiobacillus thiooxidans*. Monitoring during 114 days of operation showed that the overburden released enough alkalinity to water seeping through it to limit pyritic oxidation. There were indications that native ferrous-utilizing bacteria may have been present in the wild coal stratum. The experimental apparatus and the specific results from each reactor are described in detail. OR 70-56

MD70-8 MICROBIOLOGICAL FACTOR IN ACID MINE DRAINAGE FORMATION: A PILOT PLANT STUDY

Baker, R. A. and Wilshire, A. G. (Carnegie-Mellon Univ.), Environ. Sci. Technol. *4* (5), 401-407 (1970). This article gives the experimental procedure and the results obtained with flooded, horizontal, packed-bed reactors used to simulate dynamic conditions of actual formation of acid mine drainage by bacterial activity. It is a part of the study completed by the authors for the Appalachian Regional Commission. OR 70-44

MD70-9 MICROBIAL FACTOR IN ACID MINE DRAINAGE FORMATION: II FURTHER OBSERVATIONS FROM A PILOT PLANT STUDY

Baker, R. A. and Wilshire, A. G., Carnegie-Mellon Univ., Rept. to U.S. Dept. Int., FWQA, Water Pollut. Contr. Res. Ser. 14010 DKN 11/70 (1970). 68 pp. NTIS, PB-196 113. The effects of chemoautotrophic organisms on the production of acid mine drainage has been studied in horizontal pyritic packed-bed pilot plant reactors under aerobic and monaerobic conditions. Seeding of reactors was both by a mixture of *Thiobacillus thiooxidans*, *Ferrobacillus ferrooxidans*, and *Ferrobacillus sulfooxidans* and by each of the organisms separately. Feedwater of known composition was passed through the system at predetermined rates, and effluents were analyzed for pH, acidity, total iron, ferrous ion, and sulfate as function of flow rates. Aerobic systems were found to release greater amounts of Fe(II) and S_2-II ions and their oxidation products than nonaerobic systems. The organisms accelerated Fe(II) oxidation with no significant difference in effect on the production of acid mine drainage among the three organisms used. In supplementary studies, acid mine drainage components were increased with recycle, with forced aeration, with addition of carbon dioxide gas, and directly related to available pyritic surface. There was no evidence that mycelial growth which developed under aerobic conditions affected the production of acid drainage. The experimental methods and equipment are described in detail. Previous studies by the authors and by others on the role of bacteria in formation of acid mine drainage are discussed. OR 70-76

MD70-10 PROCESS OF TREATING ACID MINE WATER

Birch, J. J. (to Barnes & Tucker Co.), U.S. Pat. 3,516,931 (June 23, 1970). 8 pp. Water treatment for acid mine water which comprises first adding alkaline reactant such as lime in powdered form, carrying the mixture of water and powdered reactant through a rotating bed of limestone in the presence of air, thus adding calcium carbonate particles to the water, combining the water thus treated with raw acid mine

MD70-10 (continued)

water, aerating the mixture and allowing a flocculant precipitate or floc of ferric hydroxide and alumina to separate out. (Abstract of the Disclosure) OR 70-135

MD70-11 THE EFFECT OF ACID MINE WATER ON FLOODPLAIN SOILS IN THE WESTERN KENTUCKY COALFIELDS

Blevins, R. L., Bailey, H. H., and Ballard, G. E. (Univ. Ky.), Soil Sci. 110 (3), 191-196 (1970). Laboratory and greenhouse tests were carried out to assess the extent of contamination by acid drainage from surface mines in the Clear Creek floodplain, Hopkins County, Kentucky. Analysis of water samples from a stream channel, groundwater, and ponding shows a low pH which tended to increase with distance from the source of acid drainage. A comparison of the chemical properties of samples from two series of soils taken from acid wash and non-acid wash areas shows definite contamination from the acid drainage. The soils had not only a low pH, but also a concentration of exchangeable aluminum well above the amount known to restrict plant growth. In greenhouse tests, liming and fertilizer additions overcame the toxic effects of acid soils. OR 70-90

MD70-12 COAL AND COAL MINE DRAINAGE

Boyer, J. F., Jr. (Bitum. Coal Res., Inc.), J. Water Pollut. Contr. Fed. 42, 1179-1185 (1970). The third annual review of the literature is based on material included in the 1969 Supplement to "Mine Drainage Abstract -- A Bibliography." Topics included are documentation of source of mine drainage; causes and effects of mine drainage; the relation of bacteria to mine drainage; and mine drainage treatment and abatement methods. There are 49 references. OR 70-63

MD70-13 EFFECTS OF ACID MINE DRAINAGE ON WATER QUALITY OF A RESERVOIR

Brezina, E. R. (1), Campbell, R. S. (2), and Whitley, J. R. (3) [(1) Pa. Dept. Health, (2) Univ. Mo., and (3) Mo. Dept. Conserv.], J. Water Pollut. Contr. Fed. 42 (8, Pt. 1), 1429-1436 (1970). Sampling data are given to support the authors' findings that Deepwater Creek carried acid mine drainage which altered the water quality of the Montrose Reservoir, Missouri. Effect of acid drainage discharged into Deepwater Creek was measured by hourly sampling at three stations during two heavy rainfalls. Increase in acid drainage appeared to be countered by increased volume of flow. OR 70-50

MD70-14 FRESHENING ACID MINE-WATERS

Browning, J. E., Chem. Eng. 77 (1), 40-42 (1970). Described in this article are current mine drainage abatement activities of several companies: the limestone treatment system of Rochester & Pittsburgh Coal Company; lime-limestone neutralization of Peabody Coal Company; Mine Safety Appliance Research Corporation program to inhibit bacterial activity; adaptation of flash-distillation by Westinghouse Electric Corporation; ozone oxidation by Brookhaven National Laboratory; ion exchange treatment using Rohm and Haas Company Desal process; Tyco Laboratories, Inc. electro-chemical process and sodium silicate coating process; and the use of latex as a soil sealant by Uniroyal. Costs are given for several of the processes. OR 70-34

MD70-15 THE QUANTIFICATION OF REACTIVE PYRITE BY GRAIN SIZE DISTRIBUTION

Caruccio, F. T. (State Univ. Coll., New Paltz, N. Y.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 123-131. A fine grained framboidal form of pyrite is shown to be highly reactive and the cause of acid drainage. A stable pyrite, identified and illustrated, remained stable even when pulverized to 2-5 micron particles. The proportion of reactive pyrite in a total sample is estimated using various methods of microscopic analysis. The exact nature of the chemical difference between reactive and inert pyrite is currently being studied. OR 70-11

MD70-16 CHARTIERS CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT

Ackenheil & Assoc., Inc., SL-102 Phase III Rept. to Pa. Dept. Mines Miner. Ind. (1970). 272 pp. The 43 major sources of pollution of Chartiers Creek evaluated here are the most important of the 233 sources of pollution measured and catalogued in Phase I of this 18 month study. Data obtained for the major sources during the three month period of Phase II are included with the data obtained subsequently during the ten months of Phase III. Each source is described and also is located on a detailed map. Minimum, maximum, and weighted average values of pH, flow, acidity, iron, manganese, sulfate, hardness, acid load, and temperature are reported for each source. The value of surface mine reclamation is indicated by the fact that many more major sources of pollution are found in areas where surface mines are unreclaimed than in areas where reclamation projects have been carried out. A recommended priority of abatement based on percentage of acid contributed to Chartiers Creek has been made for the major pollution sources. Cost analyses are given for reclamation and for treatment. OR 70-29

MD70-17 INFLUENCES OF STRIP MINING ON THE HYDROLOGIC ENVIRONMENT OF PARTS OF BEAVER CREEK BASIN, KENTUCKY, 1955-66

Collier, C. R., Pickering, R. J., and Musser, J. J. (Editors), U.S. Geol. Surv. Prof. Paper 427-C (1970). 80 pp. In this third report in a series on the environmental effects of surface mining in McCreary County, Kentucky, Cane Branch, a stream acid from mining, is compared to Helton Branch which drains an unmined area. The paper includes separate studies on precipitation and runoff, ground water, water geochemistry, erosion and sedimentation, stream bottom fauna, fish population, microbiology of streams, and tree growth. The most obvious effects of surface mining were on the chemical composition of the water, sediment characteristics of the stream, aquatic biology, and on vegetation. The detailed data collected in the various studies are tabulated. OR 70-94

MD70-18 STRIP-MINING, EROSION AND SEDIMENTATION

Curtis, W. R. (Northeastern Forest Exp. Sta., U.S. Dept. Agr., Berea, Ky.), Ann. Meet. Am. Soc. Agr. Engr., Minneapolis, Minn., 1970. 9 pp. Suspended sediment in streams produced by surface-mining in watersheds is shown to depend more on the extent of area disturbed and whether mining operations are active than on rainfall. OR 70-91

MD70-19 DISPOSAL OF CHEMICAL SLUDGES AND BRINES

Dean, R. B. (U.S. Dept. Int., FWQA, Cincinnati, Ohio), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 367-375. Methods of dewatering and disposal of treatment wastes are discussed. The advantages and disadvantages presented show that the problems are both technical and economic. Among dewatering methods considered are lagooning, freezing, vacuum filtration, and use of centrifuges. Underground storage, deep well injection, wet application of sludge on forest and agricultural land, and dumping brines into the ocean are disposal methods discussed. OR 70-27

MD70-20 "OPERATION SCARLIFT" PROJECT SL-108 AMD POLLUTION OF THE EAST BRANCH OF THE CLARION RIVER

Doyle, F. J. (Michael Baker, Jr., Inc.), Water Pollut. Contr. Assoc. Pa. Mag. 3 (1), 12-14 (1970). The watershed survey showed that the total quantity of pollution measured as sulfuric acid loading is about four tons per day, a relatively small amount. However, much of the discharge goes directly into the East Branch Dam Reservoir. The article describes the area, its mining history, past corrective measures used, the water quality, water flow testing programs carried on under this project, and problems encountered because of lack of records of early mining activity. OR 70-48

MD70-21 TREATMENT PLANT SECOND STAGE IN CLEAN STREAMS "OPERATION SCARLIFT" ON CLARION RIVER BRANCH

Doyle, F. J. (Michael Baker, Jr., Inc.), The Baker Engr. 18 (1), 11-14 (1970). The lime neutralization plant to be built above an inlet to the reservoir on the East Branch is described. OR 70-49

MD70-22 DRAINAGE

Coal Age 75 (10), 134-136 (1970). Water handling methods and treatment facilities at several mines in southwestern Pennsylvania are discussed in this issue on production of coal for power plants in Chestnut Ridge. Water contact with acid-forming materials is kept to a minimum. Details of the lime treatment at Barnes and Tucker Lancashire No. 20 mine are given. OR 70-64

MD70-23 PANEL ON SLUDGE HANDLING AND DISPOSAL

Draper, J. C. (1), Godard, R. R. (2), Olsen, D. (3), Rinne, W. W. (4), and Steinman, H. E. (5) [(1) Duquesne Light Co., (2) U.S. Steel Corp., (3) Pittsburgh Coal Co., (4) U.S. Office Saline Water, and (5) Jones & Laughlin Steel Corp.], Third Symp. Coal Mine Drainage Res., Pittsburgh, Pa., May 19-20, 1970. Draper, Godard, and Steinman discuss disposal of sludge in abandoned areas of mines. Steinman also discusses experience in permanent lagoon storage. Olsen emphasizes problems of sludge draw-off from settling ponds and describes the "hydraulic rake" developed at Consolidation Coal to overcome rat-holing. Rinne's remarks referred generally to brines from all desalting processes and included discussion of sub-surface injection, evaporation, and transport to the ocean as methods of disposal. OR 70-31

MD70-24 REMOVAL OF MINE WATER IONS BY MICROBIAL POLYERS

Dugan, P. R. (The Ohio State Univ.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 279-283. Zoogloea ramigera isolate 115, produced a polysaccharide that had a strong affinity for metal ions. Both anions and cations, particularly iron and sulfate, were adsorbed to a degree to warrant further investigation. OR 70-23

MD70-25 AEROBIC HETEROTROPHIC BACTERIA INDIGENOUS TO pH 2.8 ACID MINE WATER: MICROSCOPIC EXAMINATION OF ACID STREAMERS

Dugan, P. R., MacMillan, C. B., and Pfister, R. M. (The Ohio State Univ.), J. Bacteriol. 101 (3), 973-981 (1970). The study of acid streamers from an identified mine discharge suggests that they consist of microcolonies of different types of bacteria and precipitated inorganic compounds trapped in an extra-cellular fibrillar polymer network. OR 69-91

MD70-26 ACID MINE DRAINAGE CONTROL - A PROGRESS REPORT

Escher, E. D. (Cyrus Wm. Rice Div., NUS Corp.), 31st Ann. Meet., Intern. Water Conf., Engr. Soc. West. Pa., Pittsburgh, Pa., 1970. 16 pp. Methods in use or under study for controlling acid mine drainage are reviewed. Included are reclamation and revegetation of surface-mined lands and neutralization and iron removal processes. The bibliography gives sources of information for each abatement or treatment method discussed. OR 70-81

MD70-27 EXPERIMENTAL MINE DRAINAGE TREATMENT FACILITY HOLLYWOOD, PENNSYLVANIA

The Pa. State Univ., University Park, Pa. (undated). 2 pp. This small brochure gives the flowsheet of the treatment plant. The operation of the plant and the six types of mine drainage treatment systems which are available in this research facility are discussed. OR 70-100

MD70-28 EXTENT OF COAL MINE DRAINAGE POLLUTION: McMAHON CREEK WATERSHED, OHIO

U.S. Dept. Int., FWQA, Upper Ohio Basin Office, Work Document No. 34 (1970). 38 pp. The area investigated in the field study is described in detail and the sources of acid drainage from mining activity are identified. Results of stream water quality studies are tabulated. Data are reported for flow, specific conductance, total net acidity, hardness, sulfate, total iron, manganese, and aluminum. The report includes recommendations for further study and for a program of abatement of the pollution of McMahon Creek. OR 70-39

MD70-29 FEASIBILITY STUDY MANUAL - MINE WATER POLLUTION CONTROL DEMONSTRATIONS

Rept. by U.S. Dept. Int., FWQA, Water Pollut. Contr. Res. Ser. 14010 FLW 07/70 (1970). 65 pp. NTIS, PB-197 594. The procedures to be followed and the information required in submitting an application for a grant under Section 14 of the Federal Water Pollution Control Act as amended are described. Appendix C gives a cursory review of the present status of mine drainage abatement technology. Appendix D "Typical data sources" lists, with their addresses, the governmental agencies and River Basin Commissions which are sources of information on water resources, stream quality, hydrology, geology, topography, and meterology. OR 70-74

MD70-30 FEASIBILITY STUDY OF MINING COAL IN AN OXYGEN FREE ATMOSPHERE - A DEMONSTRATION OF A NEW MINING TECHNIQUE TO PREVENT THE FORMATION OF MINE ACID IN AN ACTIVE DEEP MINE - PHASE I

Island Creek Coal Co. and Cyrus Wm. Rice Div., NUS Corp., Rept. to U.S. Dept. Int., FWQA, Water Pollut. Contr. Res. Ser. 14010 DZM 08/70 (1970). 163 pp. NTIS, PB-197 446. This is the first part of a four phase program to demonstrate that an oxygen-free atmosphere in an active mine will prevent the formation of acid mine drainage. The development of the life support system for the mines, the special equipment for controlling the mine atmosphere, special personnel training programs, and methods of collecting and recording data from the project are all described. Three mining areas in the Kanawha and Big Sandy River Basins are evaluated for their suitability as demonstration sites. Published information on acid drainage in these areas is compiled. Also, analyses of drainages for this study give values for alkalinity, acidity, chloride, specific conductance, pH, calcium, magnesium, hardness, sulfate, iron, aluminum, and manganese. pH ranges between 6.2 and 7.7. Cost of suits and life support systems and additional capital and operating costs of mining in an oxygen-free atmosphere are estimated. OR 70-87

MD70-31 SELECTION OF LIMESTONES AS NEUTRALIZING AGENTS FOR COAL MINE WATER

Ford, C. T. (Bituminous Coal Res., Inc.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 27-51. From the study of the chemical and physical properties of 14 selected limestones, guidelines for the choice of limestones for neutralizing mine water are given. The particle size should be at least as small as 74 microns and preferably smaller. The most effective limestones are most nearly pure calcium carbonate. The stones which have a relatively low calcium content but which contain calcite and have a large surface area are also effective neutralizers. Magnesite and dolomitic limestones are much less reactive. OR 70-6

MD70-32 EVALUATION OF POLLUTION ABATEMENT PROCEDURES IN MORAINE STATE PARK

Foreman, J. W. (Gwin Engineers, Inc.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 304-333. Surface mine reclamation, deep mine wet seals, grouting, surface sealing, refuse pile removal, and oil well plugging are remedial methods being evaluated in a 25 square mile area in Butler County, Pennsylvania. Samplings and flow measurements at known mine drainage points have been made at least once a month since May 1967. Information on flow in gallons per minute and on pH, alkalinity, acidity, iron, and manganese has been tabulated. Discharges both from deep mines that have been wet sealed and from reclaimed surface mine areas have shown a reduction in acidity. The lake being made in the park has been sampled

MD70-32 (continued)

at intervals while it has been filling and has not been found acid. OR 70-25

MD70-33 FORESTRY RESEARCH: FREEING STREAMS FROM MUD & FLOOD

U.S. Dept. Agr., Northeastern Forest Exp. Sta., Forestry Sci. Photo Story No. 13 (undated). 4 pp. Methods of surface-mine reclamation designed to prevent erosion and to control silt are illustrated. OR 70-106

MD70-34 FORESTRY RESEARCH: TOWARD A QUALITY WATER SUPPLY

U.S. Dept. Agr., Northeastern Forest Exp. Sta., Forestry Sci. Photo Story No. 10 (undated). 4 pp. Tests carried out on three tributaries of Leatherwood Creek in eastern Kentucky coal fields are described. Mining practices which minimize water pollution are briefly reviewed. OR 70-105

MD70-35 MINE WATER TREATMENT - FRICK DISTRICT

Godard, R. R. (U.S. Steel Corp.), Mining Congr. J. 56 (3), 36-40 (1970). The H. C. Frick Coke Company used limestone neutralization of acid water from 1913 to 1926 and also investigated commercial uses of the sludge. OR 70-33

MD70-36 THE RELATION OF REFUSE PILE HYDROLOGY TO ACID PRODUCTION

Good, D. M., Ricca, V. T., and Shumate, K. S. (Ohio State Univ.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 145-151. The refuse pile and its hydrologic characteristics are shown in a map. Data on precipitation, runoff, and changes in ground-water storage are gathered from small watersheds instrumented with raingages, flumes, and observation wells. The results indicate that the pyrite oxidation takes place only in the top several inches of the pile at a uniform rate between rains and is flushed out during storms. OR 70-14

MD70-37 FERRIC ION OXIDATION OF PYRITE

Grove, D. R., M.S. Thesis, The Ohio State Univ., 1970. 56 pp. The primary objective of the program was to test the assumption that free ferric ion is the active oxidizing species of pyrite in the formation of acid mine drainage. The laboratory method and the apparatus devised to carry it out are described. Also, the theoretical basis of the work is discussed. A conclusion of the study is that the rate of pyrite oxidation by ferric ion is a function of the free ferric-ferrous ratio. Some attention was given to effects of pH and of iron concentration, but further study of these factors is recommended. OR 70-68

MD70-38 HIGH DENSITY SLUDGE PROCESS FOR TREATING ACID MINE DRAINAGE

Haines, G. F., Jr. and Kostenbader, P. D. (Homer Res. Lab., Bethlehem Steel Corp.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 12-26. A controlled volume of sludge is recycled and mixed with lime slurry before being added to mine water. The process is based on laboratory tests showing that sludge recycling could increase the solid content of the sludge from treating high ferrous iron water. Further work showed that ferrous to ferric iron ratio controlled the character of the sludge. Laboratory and pilot plant studies to define the variables affecting the process and to develop operating guidelines and engineering data are given in detail. Operation of a demonstration plant at Bethlehem's Mines in Cambria County, Pennsylvania, where resulting sludge was disposed of in an abandoned area of the mine is described. OR 70-5

MD70-39 RECENT LEGISLATION AFFECTING MINE DRAINAGE RESEARCH

Hall, E. P. (U.S. Dept. Int., FWQA, Washington, D.C.), Third Symp. Coal Mine Drainage Res., Pittsburgh, Pa., by Coal Ind. Advisory Comm. to ORSANCO, 1970. 6 pp.

MD70-39 (continued)

The provisions of Section 14 of the Water Quality Improvement Act of 1970 are discussed. Programs funded under this section are to demonstrate feasibility of mine drainage abatement techniques. OR 70-77

MD70-40 CONTROL OF ACIDIC MINE DRAINAGE

Hartford, W. H., Science 169, 504 (1970). This communication proposes the prevention of pyrite oxidation by use of slightly soluble chromate dispersed in an adherent hydrophilic coating applied to the mine face. OR 70-59

MD70-41 MINE DRAINAGE POLLUTION - STILL A STEPCHILD

Heine, W. N. (Skelly and Loy, Consulting Engrs.), Water Pollut. Contr. Assoc. Pa. Mag. 3 (6), 4-7 (1970). The extent of the mine drainage problem, particularly from abandoned mines, is reviewed. Legislative action to control pollution from active mines and to provide funds to abate pollution from abandoned mines is discussed. OR 70-101

MD70-42 TREATMENT OF MINE DRAINAGE BY INDUSTRY IN PENNSYLVANIA

Heine, W. N. and Giovannitti, E. F. (Bur. Sanit, Eng., Pa. Dept. Health), J. Sanit. Eng. Div., Proc. Am. Soc. Civil Engr. 96 (SA 3), 743-755 (1970). The status of mine drainage treatment technology as exemplified by five treatment plants in Pennsylvania is evaluated. Drainages are from the mining of Lower Kittanning, Clarion, Upper Freeport, and Pittsburgh seams. One of the two drainages from the Pittsburgh seam is highly alkaline. Treatment at each plant includes some combination of neutralization, aeration, and settling. Values for plant and aeration influent and effluent are tabulated for field and laboratory pH, field temperature, dissolved oxygen, alkalinity, sulfate, turbidity, solids, magnesium, zinc, aluminum, manganese, nickel, lead, iron, copper, chromium, calcium, and arsenic. Manganese removal, lime feeding, sludge disposal, and aeration are also discussed. OR 70-84

MD70-43 ELKINS MINE DRAINAGE POLLUTION CONTROL DEMONSTRATION PROJECT

Hill, R. D. (U.S. Dept. Interior, FWQA, Cincinnati, Ohio), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 284-303. The demonstration project was begun in 1964 on an area containing a 3000 acre drift mine and a number of smaller underground mines as well as over 1000 acres that had been disturbed by surface mining. The effectiveness of mine sealing and land reclamation measures for the first two years following their construction are evaluated in this report. The tabulated data of pollution load of the main streams and subwatershed in the area show that although the runoff from reclaimed and revegetated areas showed some improvement, air sealing of underground mines was not successful. OR 70-24

MD70-44 LIMESTONE TREATMENT OF ACID MINE DRAINAGE

Hill, R. D. (1) and Wilmoth, R. C. (2) [(1) U.S. Dept. Int., FWQA, Cincinnati, Ohio and (2) U.S. Dept. Int., FWQA, Norton, W. Va.], SME Fall Meet., St. Louis, Mo., 1970. 24 pp. The state-of-the-art of limestone treatment of acid mine waters is presented. The advantages and disadvantages of the method and its general applicability are discussed. Low iron-low acid drainage is identified as easiest to treat while high ferrous iron drainage is considered most difficult. OR 70-60

MD70-45 LIMNOLOGICAL SURVEY OF A SECTION OF THE SUSQUEHANNA RIVER (II)

Himes, C. L. and Rimple, R. (Bloomsburg State College), Pa. Acad. Sci. 44, 112-115 (1970). Daily and diurnal samples for dissolved oxygen (ppm and % saturation), water temperature and pH, free carbon dioxide (mg/l), and total alkalinity (mg/l) were taken at three stations on a section of the Susquehanna River, North Branch, near Bloomsburg, Pa. in the summer of 1968. Data were compared to similar sampling

MD70-45 (continued)

in 1966 and 1963. Mine acid water treatment and more-normal rainfall seem to have brought about an improvement in the quality of the river water. (Authors' abstract) OR 70-133

MD70-46 AN EXPERIMENTAL INVESTIGATION OF THE TREATMENT OF ACID MINE WATER CONTAINING HIGH CONCENTRATIONS OF FERROUS IRON WITH LIMESTONE

Holland, C. T. (W. Va. Univ.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburg, Pa. (1970). pp 52-65. Results of the 12 tests reported from this ongoing program were obtained from November 1, 1968 through May 30, 1969. Acid mine water was effectively treated with a combination of limestone and lime introduced in that order at separate points. Aeration of untreated water, either in shallow holding ponds or through forced aeration, aids in the treatment since oxidation of ferrous to ferric iron is enhanced. Ferric iron can then be readily precipitated by limestone. In the brief discussion on sludge the difference between that formed from lime treatment and that formed from limestone treatment is questioned. OR 70-7

MD70-47 SULFATE REDUCTION BY SULFATE-REDUCING BACTERIA

Hsu, C., M.S. Thesis, Syracuse Univ., 1970. 65 pp. Experiments have been carried out to evaluate a treatment of acid mine water in which bacteria in the presence of a carbon source would reduce sulfate to sulfide. Sulfides would then combine with ferrous iron to precipitate ferrous sulfide and also would form hydrogen sulfide gas removing both sulfur and iron and raising the pH of mine water. Laboratory studies indicate that the bacterial sulfate reduction treatment can be adapted to raw mine water. OR 70-88

MD70-48 BIOLOGICAL TREATMENT OF ACID MINE WATER

Hsu, C. and Rice, P. A. (Syracuse Univ.), Eng. Ext. Ser. No. 137, Purdue Univ., Proc. 25th Ind. Waste Conf., 1970. pp 662-672. The work carried out to evaluate a proposed treatment of acid mine drainage by sulfate reducing bacteria is reported. OR 70-89

MD70-49 ACID MINE DRAINAGE IN CANE CREEK BASIN, NEAR OAKMAN, WALKER COUNTY, ALABAMA

Hyde, L. W., Geol. Surv. of Ala., Circular 64 (1970). 19 pp. This study, carried out cooperatively with the Alabama Highway Dept., reports the effects of acid water on materials used for road culverts. Test sections of pipes made from concrete, galvanized steel, bituminous-coated galvanized steel, cladded aluminum, and bituminous-coated cladded aluminum were installed in a stream site that had a pH of about 3. After one year in place, the concrete and uncoated metal pipes showed definite deterioration. The coated pipes were corroded only where the bituminous coating had been damaged, leaving unprotected areas. OR 70-124

MD70-50 INERT ATMOSPHERE IN MINES COULD ABATE ACID DRAINAGE

Chem. Eng. News 48 (21), 33-35 (1970). Cyrus Wm. Rice Division, NUS Corporation, has proposed pressurizing deep mines with an inert gas to keep oxygen from pyrites and reduce acid mine drainage. A life support system, described here, would allow the principle to be applied to working as well as abandoned mines. OR 70-55

MD70-51 INVESTIGATIVE MINE SURVEY OF A SMALL WATERSHED

Halliburton Co., Rept. to U.S. Dept. Int., FWQA, Water Pollut. Contr. Res. Ser. 14010 DMO 03/70-A (1970). 89 pp. NTIS, PB-196 110. The project in the area of Browns Creek, a tributary of the West Fork River in the Monongahela River watershed includes a survey to locate sources of mine drainage and an evaluation of water quality of the creek. Thirty openings in addition to 51 openings previously located

MD70-51 (continued)

were found. A conclusion is that there was such a variety of conditions in the mine openings that no one abatement method would apply to all. Water quality data reported for stream locations, mine openings, and wells include well fluid level, stream flow, conductance, pH, acidity, alkalinity, hardness, iron, sulfate, and aluminum. A comparison of water quality data from mined and unmined areas shows that while mining operations affect water table levels, they affect the quality of water mainly in the streams. OR 70-75

MD70-52 GETTING THE FACTS AT HOLLYWOOD (PA.)

Jones, D. C., Coal Mining Process. 7 (8), 28-33 (1970). The Hollywood Experimental Mine Drainage Treatment Facility of The Pennsylvania State University is a pilot plant designed to give information needed to control pollution from acid mine drainage. The three drainages available to the plant differ in acidity, volume, and in content of total iron, ferrous iron, aluminum, calcium, magnesium, and sulfate. The treatment plant consists of a pumping station for each of the three sources, a holding lagoon, feed units for lime, sodium hydroxide, and sodium carbonate, flash mixer, oxidation unit, rock filter, Densator Unit, limestone neutralization unit, polyelectrolyte feed unit, settling lagoon, drum sludge vacuum filter, sludge drying lagoon, control building, and a garage-storage unit. The processes are monitored either by probes measuring pH, oxidation-reduction potential, and dissolved oxygen or by provisions for taking samples for laboratory analysis. Treatment plans being evaluated are combinations of oxidation, neutralization, and sludge handling methods, and include iron oxidation promoted by bacteria. OR 70-46

MD70-53 MINE DRAINAGE CONTROL--DESIGN FOR RECLAMATION AND NEUTRALIZATION

Koehrsen, L. G. (1) and Grandt, A. F. (2) [(1) Stanley Consultants (2) Peabody Coal Co.], Eng. Ext. Ser. No. 137, Purdue Univ., Proc. 25th Ind. Waste Conf., 1970. pp 465-471. This paper describes neutralization work done by Peabody Coal Company at their Will Scarlet Mine in southern Illinois. Peabody plans to reclaim the surface mined area and to channel all the drainage acid water to a central location. Several neutralization processes are being investigated. OR 70-129

MD70-54 THE RECLAMATION OF ACID MINE WATER BY REVERSE OSMOSIS

Kremen, S. S., Nusbaum, I., and Riedinger, A. B. (Gulf Gen. Atomic, Inc.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 241-266. Reverse osmosis in general and its early application to acid mine drainage improvement is reviewed. Recent work, results of two 13 week field tests and a follow-up test at Norton, West Virginia field site is reported in detail. Cost figures presented are considered to be similar for projections for reverse osmosis treatment of any brackish stream. OR 70-21

MD70-55 REVERSE OSMOSIS FIELD TESTING ON ACID MINE WATERS AT NORTON, WEST VIRGINIA

Kremen, S. S., Riedinger, A. B., Sleigh, J. H., and Truby, R. L. (Gulf Gen. At., Inc.), U.S. Office Saline Water, Res. Develop. Prog. Rept. No. 586 (1970). 44 pp. These studies of the demineralization of acid mine drainage by reverse osmosis were conducted on various types of units. Feed water recovery up to 92 percent was achieved without great difficulty. OR 70-114

MD70-56 BIOLOGICAL SURVEY OF THE UPPER POTOMAC RIVER AND SELECTED TRIBUTARIES 1966-1968

Labuy, J. L., U.S. Dept. Interior, FWQA, Charlottesville, Va., Data Rept. No. 4 (undated). 59 pp. Bottom macroorganisms were selected as indicative of the biological conditions in the stream. Samples collected at 92 stations indentified in the report are recorded in two tables. One table gives the dominant forms of bottom

MD70-56 (continued)

organisms and the indicated water quality and the other lists the organisms found and, when possible, gives quantitative results. The effects of mine drainage are indicated either by lack of sensitive clean-water associated bottom organisms or by the presence of pollution tolerant forms. OR 70-67

MD70-57 AN INVESTIGATION OF THE NATURAL BENEFICIATION OF COAL MINE DRAINAGE

Lachman, R. I. and Lovell, H. L., Pa. State Univ., Spec. Res. Rept. SR-76 to Pa. Coal Res. Bd., May 15, 1970. 187 pp. This work was done to verify the fact that mine drainage is upgraded as it flows in natural systems, although natural beneficiation shown by stream and pond studies did not bring the water quality up to state standards. Change in the total loading of iron in the stream was the best measurement of beneficiation. Some extra means of aeration was recommended to aid natural beneficiation. OR 70-131

MD70-58 KINETICS OF PYRITE OXIDATION

Larez, A. L., M.S. Thesis, The Ohio State Univ., 1970. 40 pp. The broad program on pyrite oxidation at The Ohio State University is reviewed as the background for this thesis. In this study, the rates of oxidation of samples of naturally occurring coals and shales were determined in a Warburg-type apparatus as micrograms of oxygen consumed per hour per volume of sample. The apparatus was calibrated against "sulfur ball" pyrite. Oxidation rates were determined under three conditions: first for samples as taken from the mine; then with the addition of bacteria, which are not identified; and finally after the samples had been treated with chlorine. Bacteria are shown to significantly affect oxidation of pyrite in coal but not in shale. Average oxygenation rates are tabulated. Values for individual runs are given in the appendix. OR 70-69

MD70-59 THE ROLE OF BACTERIA IN PYRITE OXIDATION KINETICS

Lau, C. M., Shumate, K. S., and Smith, E. E. (Ohio State Univ.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 114-122. Several significant findings are presented from the work to develop a kinetic model "sufficiently complete to quantitatively describe the rate of bacterial catalysis of pyrite oxidation under any given set of environmental conditions." Among the conclusions are that the iron oxidizing bacteria are able to increase the rate of pyrite oxidation by maintaining a high ferric/ferrous ratio in the solution in contact with pyrite; and that the cellular rate of production of ferric ions depends on the total number of cells near enough to allow diffusion of ferric iron back to the pyrite surface. The water/pyrite ratio determines oxygen and soluble iron diffusion rates and pH of the water as well as determining the degree of bacterial catalysis in a system since the organisms reach a limiting concentration of 10^8-10^9 cells/ml. The laboratory work was done on simulated ground water inoculated with drainage from an Ohio research mine site and a refuse pile near DuQuoin, Illinois. OR 70-10

MD70-60 COMMUNITY METABOLISM IN ACID AND ALKALINE STRIP-MINE LAKES

Lind, O. T. (1) and Campbell, R. S. (2) [(1) Baylor Univ. and (2) Univ. of Missouri], Trans. Amer. Fisheries Soc. 99 (3), 577-582 (1970). In this project community Biotic metabolism was measured for a 24 month period in three Missouri strip-mine lakes. Water pH ranged from 3.2 to 8.1. Biotic diversity was inversely related to acidity. Daily and annual photosynthesis values were monitored. Community function in these acid and alkaline strip-mine lakes, judged by rates of photosynthesis and respiration, compares favorably with community function in non-acid natural waters. (From authors' abstract) OR 70-122

MD70-61 THE PROPERTIES AND CONTROL OF SLUDGE PRODUCED FROM THE TREATMENT OF COAL MINE DRAINAGE WATERS BY NEUTRALIZATION PROCESSES

Lovell, H. L. (Pa. State Univ.), Third Symp. Coal Mine Drainage Res. Preprints,

MD70-61 (continued)

Pittsburgh, Pa. (1970). pp 1-11. General information on sludge handling and physical and chemical properties of sludge are discussed. The Experimental Mine Drainage Treatment Facility at Hollywood, Pennsylvania, described in detail, was set up to evaluate various aspects of control of sludge formation, fluid-solid separation, sludge dewatering, and sludge handling. OR 70-4

MD70-62 MINE DRAINAGE POLLUTION ABATEMENT - THEORY & PRACTICE

Maneval, D. R. (Pa. Dept. Mines Miner. Ind.), 84th Ann. Meet., Coal Mining Inst. Am., Pittsburgh, Pa., 1970. 5 pp. The author reviews the formation and character of acid mine drainage and describes Pennsylvania's program to deal with this type of water pollution. OR 70-79

MD70-63 MULTI-STAGE FLASH EVAPORATION SYSTEM FOR THE PURIFICATION OF ACID MINE DRAINAGE

Maneval, D. R. (1) and Lemezis, S. (2) [(1) Pa. Dept. Mines Miner. Ind. and (2) Westinghouse Electric Corp.], SME of AIME Fall Meet., St. Louis, Mo., 1970. Preprint 70B303. 11 pp. The theoretical background of a recirculating multistate flash evaporator is given. A plant treating 5 million gallons per day of acid mine water from an outfall near Wilkes-Barre, Pennsylvania was being designed at the writing of this paper. OR 70-103

MD70-64 TREATMENT OF ACID MINE DRAINAGE BY REVERSE OSMOSIS

Mason, D. G. (Rex Chainbelt, Inc.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 227-240. A 200 gallon sample of mine drainage was shipped from Pennsylvania to San Diego, California, for laboratory testing as the basis for design of a demonstration field testing unit. Eighteen porous fiberglass tubes of half inch diameter on which cellulose acetate membranes were cast directly were connected in series to make up one module. The unit contained 70 modules. The membranes were coated by a brown precipitate during the first 400 hours of testing. Of several chemicals used to flush the unit, sodium sulfite was most successful in improving the flow rate. OR 70-20

MD70-65 ACID MINE WASTE POLLUTION ABATEMENT SAND COULEE CREEK, MONTANA

McArthur, G. M., M.S. Civil Eng. Thesis, Montana State Univ., Final Rept. to Div. Environ. Sanit., Montana Bd. Health, Dec. 1970. 133 pp. The extensive mine drainage pollution of Sand Coulee Creek and some of its tributaries is mainly from abandoned underground coal mines. A field survey was conducted to determine the extent and sources of pollution. After a literature search several methods to reduce mine water flow and to neutralize acidity were selected for laboratory evaluation. Based on this work, two facilities are proposed for further study: a neutralization plant using limestone in a revolving drum; and mine flooding using an earthfill dam. Cost estimates for both facilities and detailed results of the field survey and of analyses of samples of streams and mine discharges are given in appendixes. OR 70-123

MD70-66 SURFACE MINE RECLAMATION, MORAINE STATE PARK, PENNSYLVANIA

McNay, L. M., U.S. Bur. Mines, IC 8456 (1970). 28 pp. The methods and costs of reclaiming two different surface-mined areas within Moraine State Park were compared. One purpose of reclamation was the control of acid mine drainage to Muddy Creek, whose waters would fill the lake being formed in the park. OR 70-52

MD70-67 THE NEED FOR A HYDROGEOLOGIC EVALUATION IN A MINE DRAINAGE ABATEMENT PROGRAM: A CASE STUDY: TOMS RUN, CLARION COUNTY, PENNSYLVANIA

Merritt, G. L. and Emrich, G. H. (Pa. Dept. Health), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 334-364. The geology and hydrology of

MD70-67 (continued)

the area are described. The water quality of the discharges of various aquifers is given and compared with typical analyses of deep well brines and acid mine drainage to show that mine drainage affects ground water. OR 70-26

MD70-68 APPLIED ADVANCE TECHNOLOGY TO ELIMINATE AERATION IN MINE WATER TREATMENT

Mihok, E. A. (U.S. Bur. Mines, Pittsburgh, Pa.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 181-187. Activated carbon catalyzed the oxidation of ferrous to ferric iron in laboratory batch tests on raw mine water. Details of the experimental work are given. OR 70-17

MD70-69 MINE WATER RESEARCH: PLANT DESIGN AND COST ESTIMATES FOR LIMESTONE TREATMENT

Mihok, E. A., U.S. Bur. Mines, RI 7368 (1970). 13 pp. The plant design and cost estimates for limestone treatment of acid mine waters of widely varying quality and quantity are given. The holding pond ahead of the treatment plant is designed with a capacity of at least three times the expected maximum daily mine water flow. Two sludge settling and concentration ponds are planned to be used alternately to permit the sludge to compact, and are designed to accumulate sludge over a 10 year period. OR 70-2

MD70-70 USE OF ACTIVATED CARBON FOR MINE WATER TREATMENT

Mihok, E. A. (U.S. Bur. Mines, Pittsburgh, Pa.), ACS Div. Fuel Chem. Preprints 14 (1), 51-57 (1970). The results of laboratory work done at the Bureau of Mines are given and show that ferrous iron oxidation in acid mine water is catalyzed by activated carbon. OR 70-36

MD70-71 MINE DRAINAGE POLLUTION ABATEMENT MEASURES FOR THE BEECH CREEK WATERSHED

Gannett Fleming Corddry and Carpenter, Inc., Rept. to Pa. Dept. Mines Miner. Ind., Proj. No. SL-111 (Dec. 31, 1970). 57 pp.+ The watershed is located in portions of Centre and Clinton Counties, within the Susquehanna River Basin. In the field survey, carried out from the fall of 1968 to the fall of 1969, 184 mine drainage discharge points were located. All discharges were gauged, sampled, and analyzed during dry, normal, and wet weather, for pH, iron, acidity, and sulfate. Some samples were also analyzed for aluminum, manganese, and total solids. The water flow routes into, through, and out of the deep mine workings were established as a preliminary to planning abatement measures. The recommended abatement plan, which includes land reclamation, and water collection and treatment, is divided into several parts to be carried out in different areas of the watershed. Cost estimates and priority for implementing the various stages of the plan are given. OR 70-127

MD70-72 AIR-SEALING COAL MINES TO REDUCE WATER POLLUTION

Moebs, N. N. and Krickovic, S., U.S. Bur. Mines, RI 7354 (1970). 33 pp. A 77 acre above-drainage coal mine was air sealed. A comparison of the chemical analyses of the mine effluent during the two year, seven month period before sealing and during the two year, eight month period after sealing shows that the acid load has been reduced. The stratigraphy and hydrology of the mined area are given. Mine breathing was investigated by making calculations based on acid load of effluent, oxygen level from air sampling, and barometric pressure changes. The construction features of the seal are described and the costs are summarized. OR 70-1

MD70-73 BEAVER IN ACID MINE DRAINAGE

Moore, J. A. (1) and Larson, J. S. (2) [(1) U.S. Dept. Int., Bur. Outdoor Recreation (2) Univ. Mass., Mass. Coop. Wildlife Res. Unit], Chesapeake Sci. 11 (1), 63-64 (1970). Beaver were observed living in a mine drainage polluted tributary to

MD70-73 (continued)

Bingamon Creek, W. Va. close to clean non-acid water. The dams and beaver fur seemed to be yellowed from iron hydroxide precipitate. OR 70-132

MD70-74 PYRITE SYSTEMS: A MATHEMATICAL MODEL

Morth, A. H., Smith, E. E., and Shumate, K. S. (Ohio State Univ.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 132-137. The development of a mathematical model of mine drainage production will be based on data from the McDaniels Research Complex, a small drift mine, and from the Truax Traer refuse pile. OR 70-12

MD70-75 NEW MINE SEALING TECHNIQUES FOR WATER POLLUTION ABATEMENT

Halliburton Co., Rept. to U.S. Dept. Int., FWQA, Water Pollut. Contr. Res. Ser. 14010 DMO 03/70 (1970). 163 pp. NTIS, PB-196 736. In this continuation of an earlier study remedial work on seals placed previously and work to improve sealing methods is carried out. Laboratory, pilot, and field studies are described in detail and are illustrated by diagrams and photographs. Water quality and flow data include values for conductance, pH, acidity, alkalinity, hardness as $CaCO_3$, iron, sulfate, and aluminum. A permeable plug of limestone to control and treat mine drainage flow at the same time did not reduce the rate of flow in field testing, but did noticeably improve the quality of the mine drainage. Costs of the work are reported. OR 70-82

MD70-76 REPUBLIC STEEL COUNTERACTS ACID MINE DRAINAGE

Nickeson, F. H., Coal Mining Process. 7 (9), 36-38 (1970). The automated mine drainage treatment plant at the Banning No. 4 Mine in Westmoreland County, Pennsylvania is described. Neutralization is carried out by lime slurry with sludge recycle. Treated water of pH 8.3 is discharged to the Youghiogheny River and 5 percent effluent is pumped to a settling basin. OR 70-62

MD70-77 ORSANCO 1970: 22ND YEARBOOK

Ohio River Valley Water Sanitation Comm., Cincinnati, 1970. 36 pp. A major part of the report is the summary of quality conditions in the Ohio River and some of its major tributaries for 1969. OR 70-112

MD70-78 COAL MINE DRAINAGE SLUDGE UTILIZATION

Osman, M. A., Skelly, J. F., and Wood, C. D. (Swindell-Dressler Co.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 376-401. Some success was achieved using sludge as an additive to synthetic light weight aggregate, to structural brick, and to iron ore concentrate pellets for blast furnace feed. Work on recovery of iron and on application of gypsum technology to sludge was also carried out. The results of various experiments are given in detail. OR 70-28

MD70-79 THE COAL MINE DRAINAGE PROBLEM IN SOUTHWESTERN PENNSYLVANIA

Pash, E. A. (U.S. Dept. Int., FWQA, Wheeling, W. Va.), Spring Geography Conf. Environ. Pollut., Calif. State Coll., California, Pa., April 1970. 13 pp. The discussion is based on information in files and from current studies of the Monongahela River Mine Drainage Remedial Project. Conditions along the West Fork River, Tygart Valley River, Cheat River, and their major tributaries, and along the main stem of the Monongahela River are described in detail. Mine drainage source inventory studies have shown that inactive, underground mines are the greatest single contributor of stream pollution in the area. OR 70-45

MD70-80 THE EFFECTS OF MAGNESIUM ON THE ACIDITY DETERMINATIONS OF MINE DRAINAGE

Payne, D. A. and Yeates, T. E. (U.S. Dept. Int., FWQA, Evansville, Ind.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 200-226. This laboratory work shows that the presence of magnesium will result in much higher than actual values for acidity when the "hot acidity" method of analysis is used. OR 70-19

MD70-81 SLUDGE VOLUME FROM TREATMENT OF ACID MINE DRAINAGE

Pudlo, G. H., M.S. Thesis, W. Va. Univ., 1970. 51 pp. The effects on sludge volume of pH, size of vessel used to measure settling, aeration of sludge, and decantation and evaporation are evaluated. Except for drainages with very high acid and iron concentration, increase in pH results in increase in volume of sludge and the size of vessel does not affect sludge volume measurement. Aeration decreases sludge volume. Dry solids from laboratory settling tests are related to dry solids in a cubic foot of sludge from a sludge pond to give a sludge volume ratio used to calculate the volume of the sludge pond necessary for a particular drainage. OR 70-95

MD70-82 PROCESS CONTROL TECHNIQUES FOR TREATING ACID MINE-POLLUTED WATERS

Qasim, S. R. (1), Whitman, I. L. (1), and Testin, R. F. (2) [(1) Battelle Memorial Inst. and (2) Reynolds Metals Co.], Water Sewage Works 117 (Ref. No.), R240-R245 (Nov. 1970). Data from 206 water quality observations were used to prepare generalized curves of the amount of treatment chemical required per thousand gallons of feed water expressed as a function of pH and specific conductance. The curves were prepared for several neutralization and ion-exchange processes. Treatment of surface water by an industrial plant in Appalachia illustrates the use of the method. OR 70-83

MD70-83 CONTROL OF ACID POLLUTION FROM COAL REFUSE PILES AND SLURRY LAGOONS

Ramsey, J. P. (Truax-Traer Coal Co.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 138-144. A coal refuse site containing both slurry lagoons and a large irregular refuse pile at the inactive New Kathleen Mine near DuQuoin, Illinois, is being used as a demonstration project to gather data for the most effective and practical means of controlling pollution. Preparation of the site included grading, creating and instrumenting several water sheds, drilling, and fitting test wells for sampling. Experimental plots to evaluate various means of sealing refuse piles were established. The covers include several combinations of limestone treatment, topsoil, and planting. Black polyethylene membrane, sewage sludge, and limestone sludge are also being evaluated as cover and in percolation tests. OR 70-13

MD70-84 RAUSCH CREEK WATERSHED MINE DRAINAGE POLLUTION ABATEMENT PROJECT

Anthracite Research and Development Co., Inc., Rept. to Pa. Dept. Mines Miner. Ind., Proj. No. SL-112 (undated). 86 pp.+ The watershed is in western Schuylkill County where there are both active and abandoned deep and surface mines. Beginning in August 1968, a field study was carried out to identify all pollution sources and a sampling program was undertaken to analyze the discharges for pH, acidity, iron, and sulfate. Flow was also recorded. Cost summaries and recommendations are made for treatment and for reclamation of surface mined areas. Methods and cost estimates for sludge handling and disposal are also presented. OR 70-126

MD70-85 LIME SLURRY SYSTEM AT PURSGLOVE NO. 15 MINE

Ream, V. H. (Christopher Coal Co.), Mining Congr. J. 56 (1), 55-59 (1970). High ferrous iron mine drainage is treated by neutralization and aeration. The problems encountered in plant operation with control of lime flow and with sludge handling are discussed. OR 70-32

MD70-86 FLOCCULATION-FILTRATION STUDIES ON ACID COAL MINE DRAINAGE

Reese, R. D. and Neff, R. E., Am. Cyanamid Co. Rept., June 15-19, 1970. 16 pp. This evaluation of Cyanamid flocculants and filter aids was carried out at the Experimental Mine Drainage Treatment Facility run by The Pennsylvania State University at Hollywood, Pennsylvania. Although all flocculants tested had some effectiveness, SUPER-FLOC 127 Flocculant was judged to be most effective in regard to settling rate, composition density, and overflow clarity on sludges from the four different mine waters available through the treatment plant. The attempt to reduce moisture in sludges by filter aids was not conclusive since the laboratory filtration feed had too low a solids content for efficient filtration. OR 70-65

MD70-87 COAL MINING IN AN OXYGEN-FREE ATMOSPHERE

Rice, J. K. (Cyrus Wm. Rice Div., NUS Corp.), ASME Winter Ann. Meet., New York, N.Y., 1970. Preprint 70-WA/PID-4. 8 pp. The life-support suit, rebreather system, emergency backup system, refuge station, and communication system proposed to allow coal mining in an oxygen-free atmosphere are described. The dust and heat problems that will be encountered are discussed. A prime purpose of the program is to show that low oxygen in the mine will prevent formation of acid drainage. OR 70-98

MD70-88 THE USE OF INERT GAS TO ELIMINATE ACID PRODUCTION BY ABANDONED AND ACTIVE DEEP MINES

Rice, J. K. (Cyrus Wm. Rice Div., NUS Corp.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 169-179. The experimental program of filling a mine with inert gas was applied to two abandoned mines. Air leaks are critical to the success of the method and may be very difficult to find. In applying the method to an active coal mine, a full suit and rebreather system as well as gas lock entries would be needed. The feasibility study has not yet shown any significant technical obstacles. OR 70-16

MD70-89 A LIMNOLOGICAL SURVEY OF THE SUSQUEHANNA RIVER. III. BETWEEN BERWICK AND SHICKSHINNY, INCLUDING A SECTION WITH MINE-WATER DRAINAGE

Rimple, R. and Himes, C. L. (Bloomsburg State College), Pa. Acad. Sci. 44, 116-121 (1970). Daily water samples taken at several stations between Berwick and Shickshinny in the summer of 1968 revealed that the water quality was above minimum standards set in 1963 by the Department of Health. Quality of water in the section where mine water entered was indicative of how a river can "clean" itself if there is adequate rainfall to keep the water at a reasonable level. (Authors' abstract) OR 70-134

MD70-90 TREATMENT OF ACID MINE DRAINAGE BY ION EXCHANGE PROCESSES

Rose, J. L. (Burns and Roe, Inc.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 267-278. A demonstration plant now under design will be located near Philipsburg, Pennsylvania. The Desal Process, previously used successfully on acid mine drainage, includes ion exchange of sulfates for bicarbonates; two stage aeration to release carbon dioxide and to remove iron by oxidation and precipitation; and a clarifier to remove calcium and magnesium. The cost figures projected for 1 mgd and 10 mgd capacity are estimated to be within the range of costs of water treatment by other desalting methods. OR 70-22

MD70-91 COST OF RECLAMATION AND MINE DRAINAGE ABATEMENT - ELKINS DEMONSTRATION PROJECT

Scott, R. B. (1), Hill, R. D. (2), and Wilmoth, R. C. (1) [(1) U.S. Dept. Int., FWQA, Elkins, W. Va. and (2) U.S. Dept. Int., FWQA, Ohio Basin Region], SME Fall Meet., St. Louis, Mo., 1970. Preprint 70AG349. 22 pp. (U.S. Dept. Int., FWQA Publ. No. 14010 --- 10/70) This is a preliminary report of the direct and indirect costs of mine drainage control measures at the Elkins demonstration site. Tabulations show reclamation work performed and cost breakdowns for the various phases of the project. The cost analysis procedures are described. OR 70-70

MD70-92 CHARACTERISTICS OF VIABLE ANTI-BACTERIAL AGENTS USED TO INHIBIT ACID-PRODUCING BACTERIA IN MINE WATERS

Shearer, R. E. (1), Everson, W. A. (1), Mausteller, J. W. (1), and Zimmerer, R. P. (2) [(1) MSA Res. Corp. and (2) Juniata Coll.], Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 188-199. Studies on two types of bacterial inhibitors are reported. Certain strains of Caulobacter were isolated from natural inhibitory waters and were shown to inhibit acid production of laboratory test streams containing iron and sulfur oxidizing bacteria. They also gave encouraging results in field testing. Fifteen antibiotics were tested for their ability to inhibit growth of all strains of known iron and sulfur oxidizing bacteria, both on agar plates and in the laboratory acid producing flow. Three antibiotics, novobiocin, oleandomycin, and aureomycin, inhibited growth of all strains tested and reduced total acidity in the laboratory flow. OR 70-18

MD70-93 UNTITLED

Shellgren, M. (Slippery Rock State Coll., Pa.), Proc. Conf. New Approaches to Strip Mining - The Planning Concept, Lexington, Ky., by SCOPE and Environ. Awareness Soc., 1970. pp 87-94. The restoration of the Slippery Rock Creek watershed is reviewed to show that surface mining does not irretrievably ruin land and water resources. OR 70-108

MD70-94 ACIDIC MINE DRAINAGE: THE RATE-DETERMINING STEP

Singer, P. C. (1) and Stumm, W. (2) [(1) Univ. Notre Dame and (2) Harvard Univ.], Science 167, 1121-1123 (1970). The authors review their work leading to their conclusion that control of oxidation of ferrous iron is necessary for abatement of mine drainage pollution. They discuss the acceleration of the rate of ferrous ion oxygenation by microorganisms. OR 70-57

MD70-95 SLIPPERY ROCK CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT

Gwin Engineers, Inc., Rept. to Pa. Dept. Mines Miner. Ind., Proj. No. SL-110 (1970). 163 pp. The 292 square mile study area is between Muddy Creek Drainage Basin where rehabilitation is being done on Moraine State Park and the North Branch of Slippery Rock Creek on which a mine drainage treatment plant has been constructed. The geology, hydrology, and stratigraphy of the area are described in detail. Results of the stream quality evaluation include values for flow, pH, alkalinity, acidity, total iron, and sulfate. Each of 37 project areas is shown on a separate map with a description of pollution sources, the amount of acid produced, proposed abatement methods, and estimated costs. A record of precipitation in the area during the year of the study is also given. OR 70-73

MD70-96 SULFIDE TO SULFATE REACTION MECHANISM

Smith, E. E. and Shumate, K. S., Ohio State Univ., Rept. to U.S. Dept. Int., FWQA, 14010 FPS 02/70 (1970). 115 pp. NTIS, PB-199 835. In the first phase of this study, the pyritic systems in coals are classified and described, and the effects of humidity on various forms of hydrated sulfates are shown. In further work, ferric ion and oxygen were found to be independent oxidizing agents of pyrite. The role of bacteria was also studied. In addition to the 27 references, the publications based on the work in this report are also listed. OR 70-3

MD70-97 DIRECT OXIDATION BY ADSORBED OXYGEN DURING ACIDIC MINE DRAINAGE

Smith, E. E. (1), Shumate, K. S. (1), Singer, P. C. (2), and Stumm, W. (3) [(1) Ohio

MD70-97 (continued)

State Univ., (2) Univ. Notre Dame, and (3) Harvard Univ.], Science 169, 98 (1970). Smith and Shumate of Ohio State University dispute a conclusion by Singer and Stumm that direct oxidation of pyrite by adsorbed oxygen is insignificant in natural environments. Singer and Stumm answer the criticism of their use of "museum grade" rather than "sulfur ball" pyrite to obtain data on which they based their conclusions. OR 70-58

MD70-98 COAL MINE DRAINAGE TREATMENT

Smith, G. C., Steinman, H. E., and Young, E. F., Jr. (Jones & Laughlin Steel Corp.), Spring Meet. SME Coal Div., Pittsburgh, Pa., April 16-17, 1970. 10 pp. The discussion of four different mine discharges at three of Jones & Laughlin's mining operations includes analyses of feed and effluent, water, flow diagrams and description of treatment processes, variations needed in the treatments, and indications of success of the treatment by improvement of receiving streams. OR 70-30

MD70-99 METHOD OF NEUTRALIZING ACID WASTE WATER

Spinola, A. A. (to U.S. Steel Corp.), U.S. Pat. 3,511,777 (May 12, 1970). 10 pp. Cement-kiln flue dust is used to neutralize acid wastes. Results of laboratory and small pilot plant tests are reported and show that the resulting sludge settles rapidly and can easily be dewatered and handled. Analyses of mine drainage samples and cement-kiln flue dusts used are tabulated. OR 70-42

MD70-100 RADIATION TREATMENT OF MINE WASTE WATERS

Steinberg, M. and Pruzansky, J. (to U.S. AEC), U.S. Pat. 3,537,966, (Nov. 3, 1970). 2 pp. A method of removing dissolved iron oxides from acidic aqueous solutions comprising exposing the aqueous solution to gamma irradiation while aerating and contacting the solution with calcium carbonate to induce precipitation of the contained iron oxides from the solution. (Abstract of the Disclosure) OR 70-130

MD70-101 SULFIDE TREATMENT OF COAL MINE DRAINAGE

Streeter, R. C. (Bituminous Coal Res., Inc.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 152-168. Hydrogen sulfide can precipitate ferrous iron and ferrous sulfide from mine water made alkaline with limestone. A mine drainage treatment using this process would eliminate the need for an oxidation step, but has a number of limitations that are discussed. OR 70-15

MD70-102 STUDIES ON LIMESTONE TREATMENT OF ACID MINE DRAINAGE

Bitum. Coal Res., Inc., Rept. to Pa. Dept. Mines Miner. Ind. and U.S. Dept. Int., FWPCA, 14010 EIZ 01/70 (1970). 96 pp. NTIS, PB-195 282. Four identified mine waters, and synthetic mine water were used throughout the project. Fourteen limestones were characterized by x-ray and spectrochemical analyses and their reactivity in neutralization reactions evaluated. Effective limestones have high calcium content, low magnesium content, small particle size, and a relatively high specific surface area. In catalyst studies activated carbon was found most effective for ferrous iron oxidation. Sludge formation and factors affecting sludge characteristics were also studied. Conversion of sludge to magnetic form is shown to reduce sludge volume and increase solids content. Aluminum interferes with formation of magnetic sludge. Coagulant aids were found to increase the rate of settling of sludges from synthetic mine water. OR 70-51

MD70-103 SUSQUEHANNA RIVER BASIN STUDY - PREVIEW

Susquehanna River Basin Study Coordinating Comm., Rept. to Water Resour. Council (1970). 25 pp. This brochure summarizes briefly the Susquehanna River Basin Study given in a main report and 11 Appendices. OR 70-117

MD70-104 SUSQUEHANNA RIVER BASIN STUDY - APPENDIX F - WATER SUPPLY AND WATER QUALITY

Susquehanna River Basin Study Coordinating Comm., Rept. to Water Resour. Council (1970). 262 pp. Acid mine drainage is one of the considerations of this general study of water supply, use, and quality in the study area. Only Sub-Basin I is not affected by acid mine drainage. Sub-Basins III and IV show the greatest mine drainage pollution. Recommended abatement programs and estimated costs are presented. OR 70-119

MD70-105 SUSQUEHANNA RIVER BASIN STUDY - SUMMARY

Susquehanna River Basin Study Coordinating Comm., Rept. to Water Resour. Council (1970). 157 pp. The summary describes the Susquehanna River Basin, its water needs and resources and presents the recommended plan for development of water resources of the area. Priorities are set by the recommendations being divided into an Early Action Plan, which includes 13 mine drainage abatement projects, and a Framework Plan, a guide to future work, which includes 14 mine drainage abatement projects. OR 70-118

MD70-106 MICROBIAL ECOLOGY OF MINE DRAINAGE

Tabita, R., Kaplan, M., and Lundgren, D. G. (Biological Res. Lab., Syracuse Univ.), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 94-113. This study was carried out on an alkaline effluent from a bituminous coal mine in the Ohio River Valley. In assaying the water for iron oxidizing, sulfur oxidizing, and heterotrophic bacteria, two types of thiosulfate oxidizing clones were isolated. Both appeared to be Thiobacillus. One, an acid former, used thiosulfate as a preferred substrate and oxidized tetrathionate, elemental sulfur, and sulfite. The lowest pH produced by the acid formers was about 4.0. The other organism, a base former was a slower grower on thiosulfate, apparently only oxidizing thiosulfate to tetrathionate, and failed to grow heterotrophically. It did not oxidize ferrous iron during the period studies. OR 70-9

MD70-107 TREATMENT OF ACID MINE DRAINAGE

Horizons Inc., Rept. to U.S. Dept. Int., FWQA, Water Pollut. Contr. Res. Ser. 14010 DEE 12/70 (1970). 88 pp. NTIS, PB-197 470. This paper describes the investigation of three surfactants as foam producers to separate iron, calcium, magnesium, and manganese from acid mine drainage. Tests were carried out on actual and synthetic mine waters, with no treatment, with partial neutralization by lime, and with complete neutralization by limestone. Major amounts of metal ions are removed but with significant residual surfactant in the treated solution and with significant water loss to foam. OR 70-86

MD70-108 TREATMENT OF ACID MINE DRAINAGE BY OZONE OXIDATION

Brookhaven Natl. Lab., Rept. to EPA, Water Pollut. Contr. Res. Ser. 14010 FMH 12/70 (1970). 87 pp. NTIS, PB-198 225. The study concludes that an ozone process is feasible, compares economically with existing processes, and offers potential advantages in process control, reduced neutralization costs, and simplified AMD sludge handling and disposal. Costs of ozone production by electric discharge and radiation processes are compared both for on-site and central plant installations. (From authors' abstract) OR 70-97

MD70-109 TREATMENT OF ACID MINE DRAINAGE BY REVERSE OSMOSIS

Rex Chainbelt, Inc., Rept. to Pa. Dept. Mines Miner. Ind. and U.S. Dept. Int., FWQA, 14010 DYK 03/70 (1970). 35 pp. NTIS, PB-195 200. Complete information is tabulated for permeate quality from individual modules, ion balances for product water, feed water, and brine concentrate, and mass balances for iron (II), magnesium, calcium, sulfate, and manganese. Module failures were always associated with the use

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of sodium hydrosulfite in the chemical cleaning of the membranes necessitated by iron fouling. OR 70-53

MD70-110 PREVENTION OF ACID MINE DRAINAGE: SILICATE TREATMENT OF COAL MINE REFUSE PILES

Walitt, A., Jasinski, R., Keilin, B., and Gruber, A. (Tyco Lab., Inc.), Third Symp. Coal Mine Drainage Res., Pittsburgh, Pa., by Coal Ind. Advisory Comm. to ORSANCO, (1970). 17 pp. This paper is based on studies carried out for EPA, Water Quality Office and published as "Silicate Treatment for Acid Mine Drainage Prevention," Water Pollution Control Research Series 14010 DLI 02/71. OR 70-109

MD70-111 AN ECOLOGICAL APPROACH TO ACID MINE POLLUTION CONTROL

Walsh, F. M., Rept. by Eco-Control, Inc. (Nov. 1970). 21 pp. Stalked iron bacteria are isolated, identified, and shown to catalyze iron oxidation in the range of pH 3.5 to pH 4.5. The microbial activity produces an acid environment suitable for Thiobacillus ferrooxidans. Studies to develop methods of controlling acid mine drainage by control of stalked iron bacteria are proposed. OR 70-80

MD70-112 WATER POLLUTION CONTROL PLANT, ERNEST MINE COMPLEX: SPECIFICATIONS AND CONTRACT DOCUMENTS

L. Robert Kimball, Consulting Eng., prepared for Pa. Dept. Mines Miner. Ind., Proj. No. SL-107, (1970). 204 pp. The complete technical specifications for the general and mechanical construction of an acid mine drainage neutralization plant located at Creekside, Indiana County, Pennsylvania are included in this compilation of contract documents. The electrical specifications, bid under a separate contract, are also included. OR 70-128

MD70-113 THE WILKES-BARRE MINE WATER DEMINERALIZATION PLANT -- PART OF OPERATION SCARLIFT

Westinghouse Electric Corp., Philadelphia, Pa. (undated). 5 pp. This brochure features the flowsheet of the multistage flash evaporation process used in the Wilkes-Barre Plant. OR 70-104

MD70-114 NEUTRALIZATION OF HIGH FERRIC IRON ACID MINE DRAINAGE

Wilmoth, R. C. and Hill, R. D., U.S. Dept. Int., FWQA, Water Pollut. Contr. Res. Ser. 14010 ETV 08/70 (1970). 40 pp. NTIS, PB-192 087. Lime, limestone, and soda ash were used to neutralize high ferric iron mine water. Costs, reaction efficiencies, treated water qualities, and sludge characteristics are compared for the three chemicals. Soda ash, the most expensive to use, gives a high sodium effluent. Lime costs half as much as limestone, but the limestone sludge has smaller volume and higher solids content. OR 70-85

MD70-115 NEUTRALIZATION OF HIGH FERRIC IRON ACID MINE DRAINAGE

Wilmoth, R. C. and Scott, R. B. (U.S. Dept. Int., FWQA), Third Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1970). pp 66-93. Also published as Wilmoth, R. C. and Hill, R. D., U.S. Dept. Int., FWQA, 14010 ETV 08/70, 1970. 38 pp. NTIS, PB-192 087. Lime, limestone, and soda ash are compared in neutralizing high ferric iron acid mine water from Grassy Run, Norton, West Virginia. The major differences noted are that soda ash produces high sodium and low calcium and hardness, and is the most expensive to use. Lime is estimated to cost half as much as limestone, but the limestone sludge has smaller volume and higher solids content. The precision required for limestone feed control is not as great as that required for lime feed control. There was no difference in neutralization efficiency between dry feed and slurry feed of the three agents. Aeration decreased the retention time

MD70-115 (continued)

necessary after treatment, but the slight increase in neutralization efficiency was not enough to justify the added cost if retention time is not restricted by minimal lagoon capacity. The use of PVC piping and pumps with wetted parts made of 316 stainless steel in order to reduce maintenance costs of treatment systems is suggested. OR 70-8

MD70-116 UNDERGROUND COAL MINING METHODS TO ABATE WATER POLLUTION

Wilson, L. W., Matthews, N. J., and Stump, J. L., W. Va. Univ., Coal Res. Bur., Rept. to EPA, Water Pollut. Contr. Res. Ser. 14010 FKK 12/70 (1970). 50 pp. NTIS, PB-214 697. This report encompasses a literature survey of acid mine water abatement measures and mining hydrology. Mine water management is examined from the aspects of preventing water entry, preventing formation of acidic waters, underground water treatment, and water removal. Sealing methods and unique methods in deep mines are also discussed. Those areas where further research efforts might be applied are noted in the section on research needs. There are 67 references. (From authors' Introduction) OR 70-120

MD70-117 THE EVALUATION OF ENVIRONMENTAL ALTERATIONS BY THERMAL LOADING AND ACID POLLUTION IN THE COOLING RESERVOIR OF A STEAM-ELECTRIC STATION

Witt, A., Jr., Campbell, R. S., and Whitley, J. R. (Univ. Mo. - Columbia), Mo. Water Resour. Res. Cent., Completion Rept. to U.S. Office Water Resour. Res., (Aug. 31, 1970). 99 pp. The reservoir on the middle fork of the Chariton River, Missouri, receives mine drainage inflow and heated water discharge from a steam electric plant. The drainage from inactive surface mines and a coal washery holding pond has a pH of 2.8-3.4, free acidity 48-594 mg/l as $CaCO_3$, 1,000 - 26,000 mg/l sulfate, an absence of carbonate and bicarbonate alkalinity, and 1,300 - 43,000 umhos/cm specific conductance. Water quality measurements showed that except for sulfate levels, the acid water did not affect a wide area. Also, fish kills were restricted to the immediate area of acid water inflow. Detailed results of studies of fish growth, movement, and harvest in the Hotwater Arm and the Control Arm of the reservoir are reported. OR 70-111

1971

MD71-1 ACID MINE DRAINAGE

Natl. Ind. Pollut. Contr. Council, Sub-Council Rept., Feb. 1971. 13 pp. This is a very general summary of the nature of acid mine drainage and the programs for abatement of mine drainage pollution. OR 71-21

MD71-2 ACID MINE DRAINAGE CONVERTED TO POTABLE WATER

Coal Mining Process. 8 (3), 38-42 (1971). The ion exchange system used to treat mine drainage contaminated water to provide a public water supply for Smith Township Municipal Authority in Washington County, Pennsylvania is described. OR 71-13

MD71-3 ACID MINE DRAINAGE FORMATION AND ABATEMENT

The Ohio State Univ. Res. Found., Rept. to U.S. EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 FPR 04/71 (1971). 82 pp. NTIS, PB-199 835. A conceptual model of pyritic oxidation is developed. Physical, chemical, and biological factors involved in the rate of acid formation and acid drainage from pyritic systems are discussed in detail in separate sections of the report. The interpretation of data from field projects on both deep and surface mines is also discussed. There are 69 references. OR 71-20

MD71-4 ACID MINE DRAINAGE TREATMENT PROCESS TERMED SUCCESSFUL

Mining Congr. J. 57 (5), 53 (1971). The pilot plant for treatment of mine water from Consol's Levi Moore plant near Fairmont, West Virginia is briefly described. Bacteria are used to oxidize ferrous to ferric iron prior to neutralization of acid water by crushed limestone. Treated water is retained in ponds to settle out the precipitated sludge. OR 71-16

MD71-5 ACID MINE WATER NEUTRALIZATION

Colliery Guardian 219 (11), 520, 523 (1971). Bureau of Mines studies on the limestone neutralization is described and a flow-sheet of the process is shown. Also noted is catalytic oxidation of ferrous iron in mine drainage by activated carbon treatment. OR 71-86

MD71-6 COAL-MINING HYDROLOGY AND THE ENVIRONMENT, OR GIVE THE DEVIL HIS DUE

Agnew, A. F. (Wash. State Univ.), AIME Environ. Quality Conf., Washington, D.C., June 7-9, 1971. Paper EQC 37. 8 pp. Both the negative and positive aspects of the relation of hydrology to water pollution from coal mining are reviewed. Examples are cited to show how knowledge of hydrogeology can be used to alleviate or prevent problems of acid mine drainage. OR 71-83

MD71-7 COAL MINING AND ITS EFFECT ON WATER QUALITY

Ahmad, M. U. (Ohio Univ.), Proc. Groundwater Pollut. Conf., St. Louis, Mo., 1971. pp 13-52. The effects of surface and deep mining on water quality are discussed in detail with conditions of mines in Ohio serving as the main examples. OR 71-115

MD71-8 A HYDROLOGICAL APPROACH TO CONTROL ACID MINE POLLUTION

Ahmad, M. U. (Ohio Univ.), Acid Mine Drainage Workshop, Athens, Ohio, by Ohio Univ., 1971. 25 pp. Hydrology and geology of coal bearing areas are reviewed. The area of Sheban Strip Mine in Ohio is specifically described and a plan for abatement of acid production is suggested. OR 71-45

MD71-9 TEMPERATURE SURVEY OF COAL MINES PRODUCING ACID WATER

Ahmad, M. U. (1), Ghosh, B. A. (1), and Antalovich, J. W. (2) [(1) Ohio Univ. and (2) Kucera and Assoc., Inc.], Proc. 7th Intern. Symp. Remote Sensing Environ., by Willow Run Lab., Univ. Mich., and U.S. Gov. Agencies, May 17-21, 1971. pp 1109-1154. The ground temperature was measured with the help of a sensitive thermistor at a depth of 2 feet. A temperature anomaly ranging from 3°C to 10°C was observed between acid producing areas and non-acid producing areas. Surface temperatures were also measured using Barnes PRT-5 at a distance of 2 feet above the ground and an anomaly was observed ranging from 0.5°C to 3.5°C in the early morning and from 2.5°C to 7.5°C in the night. The temperature gradients were also measured for depths up to 4 feet and a higher temperature gradient was observed in the acid producing areas. The pyrite content and soil pH measured where the temperature readings were taken show that higher temperature anomaly coincides with the higher pyrite content and low soil pH. The magnitude of the surface temperature anomaly is controlled by the air temperature. Infrared imagery pictures were obtained on December 7, 1970. Acid producing areas are depicted warmer than non-acid producing areas. (From authors' abstract) OR 71-81

MD71-10 FEASIBILITY STUDY - UPPER MEANDER CREEK MINE DRAINAGE ABATEMENT PROJECT

Anderson, R. H., Stanley Consultants, Cleveland, O., Rept. to EPA, Office Res. Monit., Water Pollut. Contr. Res. Ser. 14010 HBQ 09/71 (1971). 53 pp. NTIS, PB-206 232. This report is an evaluation of the feasibility of a mine drainage control demonstration project for the site in Mahoning County, Ohio. The area has been extensively

MD71-10 (continued)

surface mined for coal and has been graded to a moderately rolling terrain with the exception of the final cut which created a deeply incised valley. Revegetation of the spoil area had only limited success, leaving the site generally devoid of tree and grass cover and subject to rapid runoff and severe erosion, and acid drainage. Recommendations include: elimination of standing pools of acidic water; regrading of the final cut to provide positive drainage; preparation of a suitable seed bed and planting of acid tolerant grasses, plants, and trees. Total estimated cost for the project is $270,000. (Author's synopsis adapted) OR 71-66

MD71-11 EVALUATION OF PYRITIC OXIDATION BY NUCLEAR METHODS

Baker, R. A., Carnegie-Mellon Univ., Rept. to EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 FII 03/71 (1971). 31 pp. NTIS, PB-198 523. It has been demonstrated in this short feasibility study that the Mössbauer effect, a nuclear resonance absorption phenomenon, may be used in conjunction with a scattering-mode detection system to monitor chemical oxidation of pyritic material. Oxidized pyritic material gave Mössbauer spectra which could be separated to indicate presence of ferric hydroxide and ferric sulfate. (From author's conclusions) OR 71-7

MD71-12 POLLUTION CONTROL OF PREPARATION PLANT WASTES - A RESEARCH AND DEMONSTRATION PROJECT

Barthauer, G. L. (Consolidation Coal Co.), AIME Environ. Quality Conf., Washington, D.C., June 7-9, 1971. Paper EQC 38. 14 pp. The site of the project is an abandoned underground mining operation in southern Illinois and consists of a refuse pile occupying approximately 40 acres and a slurry lagoon complex consisting of 50 acres. This paper presents the results of Phase I in which the system characteristics and acid formation rate of the refuse pile were determined. Acid contribution from the slurry lagoons was not determined but appears to be negligible. Experimental vegetative covers were tested for both the refuse pile and the slurry lagoon. Grass was successfully established with and without the use of topsoil, weathering well for one year. (Author's abstract adapted) OR 71-80

MD71-13 CONTROL OF MINE DRAINAGE FROM COAL MINE MINERAL WASTES PHASE I - HYDROLOGY AND RELATED EXPERIMENTS

Barthauer, G. L., Kosowski, Z. V., and Ramsey, J. P., Truax-Traer Coal Co., Rept. to EPA, Office Res. Monit., Water Pollut. Contr. Res. Ser. 14010 DDH 08/71 (1971). 148 pp. NTIS, PB-206 194. A project has been underway since 1968, at an abandoned mine located in southern Illinois, attempting to demonstrate practical means of abating pollution from coal mine mineral wastes. The site included a refuse pile occupying approximately 40 acres and a slurry lagoon complex of 50 acres. The average rate of acid formation for this refuse pile is 198 pounds of acidity, as $CaCO_3$, per acre per day. Acid contribution from the slurry lagoons appears to be negligible. As an abatement measure, a number of experimental vegetative covers were tested. Grass was successfully established with and without the use of topsoil, weathering well for one year. The long-term effects of establishing a grass cover directly on the refuse without the use of topsoil are not known at this time. The eleven appendixes give the specific data collected in the project, a list of the analytical procedures used, and cost estimates of vegetative test plots. (Authors' abstract adapted) OR 71-69

MD71-14 TOUR OF MOUNTAINEER DIVISION OPERATIONS - AUGUST 4, 1971

Beafore, F. J. (Consolidation Coal Co.), Acid Mine Drainage Workshop, Athens, Ohio, by Ohio Univ., 1971. 7 pp. Three mine drainage treatment plants of Consolidation Coal Company are described. The Levi Moore Plant is a neutralization plant with temporary sludge impounding. The Edgell Treatment Plant is a neutralization plant with permanent sludge impounding. The Micro-Bio Oxidation Plant is an experimental facility at the Levi Moore Plant. *Ferrobacillus ferrooxidans* are used to oxidize

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ferrous to ferric iron before neutralization. Conversion rates of 40 mg/1 per hour are reported. OR 71-44

MD71-15 CONCENTRATED MINE DRAINAGE DISPOSAL INTO SEWAGE TREATMENT SYSTEMS

Benoit, R. J., Balakrishnan, S., and Attwater, A. J., Environmental Research & Applications, Inc., Rept. to EPA, Office Res. Monit., Water Pollut. Contr. Res. Ser. 14010 FBZ 09/71 (1971). 76 pp. NTIS, PB-213 042. The effect of artificial iron-rich acid brines on municipal sewage treatment processes was studied in small scale. The raw brines even at a level of 20 percent or higher do not interfere with primary settling, but activated sludge digestion is completely inhibited by the acid. The brines when neutralized with lime improve primary settling and filtration, do not inhibit activated sludge. At the very high concentrations used, the neutralized brines give virtually complete removal of phosphate from primary effluent, activated sludge effluent, or anaerobic sludge digester decantate. Cost of reverse osmosis treatment of acid mine drainage to produce the iron-rich acid brine is estimated to be in the range of 73 cents per thousand gallons of acid mine water treated. Engineering analysis and costs are shown for transporting the brine from the mine site to the sewage treatment plant by rail, truck, and pipeline over distances ranging from 10 to 50 miles. (From authors' abstract) OR 71-65

MD71-16 A BIOLOGICAL AND CHEMICAL WATER QUALITY INVESTIGATION OF THE POUND RIVER WATERSHED

Rept. by Tech. Serv. Div., Va. State Water Contr. Board (undated). 54 pp. This detailed study of the Pound River, located in Virginia near the Kentucky border, was made after a preliminary investigation of a reported fish kill revealed acid mine drainage pollution. Results of biological and chemical sampling carried out at designated stations during 1970 are given. In many sections benthic life was found to be depressed or non-existent. High manganese and zinc as well as acid and high iron content were found in the most polluted sections of the river. In a live box study of the ability of the stream to support fish life, fish did not survive beyond 24 hours. Sources of mine drainage are identified. OR 71-5

MD71-17 ION EXCHANGERS SWEETEN ACID WATER

Bowen, D. H. M., Environ. Sci. Technol. 5 (1), 24-25 (1971). This descriptive article relates the method used to overcome the effects of alkaline mine drainage on the public water supply of Smith Township, a community 20 miles west of Pittsburgh. Sulfate, calcium, and magnesium are removed by ion exchange in which both anion and cation exchange resins are used. Some general costs are given for the process, including the costs of regenerating the resins. OR 71-1

MD71-18 COAL, COAL BY-PRODUCTS, AND COAL MINE DRAINAGE

Boyer, J. F., Jr. (Bitum. Coal Res., Inc.), J. Water Pollut. Contr. Fed. 43 (6), 1008-1014 (1971). The 60 publications reviewed cover the formation of mine drainage, effects of mine drainage on the environment, abatement demonstration projects, and research on treatment methods. Several review papers on specific aspects of the mine drainage problem are noted. OR 71-56

MD71-19 EFFECTS OF STRIP MINING ON SMALL-STREAM FISHES IN EAST CENTRAL KENTUCKY

Branson, B. A. and Butch, D. L., Proc. Biol. Soc. Wash. 84 (59), 507-518 (1971). Leatherwood Creek and Bear Branch Creek, Breathitt County, Kentucky were monitored to observe effects of surface mining on fish populations. Siltation, not acidity was the main pollutant resulting from surface mining. Numbers of bottom feeders declined earliest. Investigation of the stream showed that this was at least partly due to reduction of benthic food organisms and the reduction in darters and minnows, either by prevention of mating or destruction of fry and eggs. Monitoring of the streams is planned to be continued. OR 71-120

MD71-20 STREAM POLLUTION OF THE LOYALHANNA CREEK WATERSHED

Brant, J. W. (Buchart-Horn Consulting Engr. Planners), Water Pollut. Contr. Assoc. Pa. Mag. 4 (1), 4-10 (1971). The Loyalhanna Creek and its tributaries are discussed as examples of streams affected by mine drainage pollution. Among the recommendations are that the quality of upstream water be used for evaluation of downstream pollution, that sulfate be used as a criteria of extent of acid mine drainage pollution, and that any watershed investigation cover 3 to 5 water years. OR 71-12

MD71-21 SHALLOW GROUND-WATER FLOW SYSTEMS BENEATH STRIP AND DEEP COAL MINES AT TWO SITES, CLEARFIELD COUNTY, PENNSYLVANIA

Brown, R. L. and Parizek, R. R., Pa. State Univ., Spec. Res. Rept. SR-84 to Pa. Dept. Environ. Resour., May 1, 1971. 216 pp. The objective of this study was to describe the ground-water flow systems in rock units associated with coals so that acid mine drainage could be more effectively prevented, treated, isolated, or diluted as conditions may require. Two sites near Kylertown, Pennsylvania, were used for the work. Flow systems at each site were found to be very similar. Flow nets, even when interpretative are extremely useful for describing ground-water movement and should be highly beneficial in designing projects to prevent, treat, or isolate mine drainage. (From authors' Summation of Results) OR 71-106

MD71-22 ROTARY PRECOAT FILTRATION OF SLUDGE FROM ACID MINE DRAINAGE NEUTRALIZATION

Brown, T. S., Johns-Manville Products Corp., Rept. to Pa. Coal Res. Board and EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 DII 05/71 (1971). 121 pp. NTIS, PB-203 190. During 1969 and 1970, rotary vacuum precoat filtration was investigated as a means for dewatering sludge produced by the neutralization of mine drainage at four locations in Pennsylvania: Dark Water Mine, St. Clair; Rushton Mining Company, Osceola Mills; Bennett Branch and Proctor No. 2, both in Hollywood. (Authors' abstract adapted) OR 71-35

MD71-23 THE RECOVERY OF DAMAGED STREAMS

Cairns, J., Jr., Crossman, J. S., Dickson, K. L., and Herricks, E. E. (Va. Polytechnic Inst. and State Univ.), The ASB Bulletin 18 (3), 79-106 (1971). Case studies include an experimental acute acid stress on Mill Creek, a tributary to North Fork of Roanoke River, Virginia; a review of results of continuous acid stress in Indian Creek, a tributary of the Youghiogheny in Pennsylvania; an assessment of the recovery of Little Scrubgrass Creek in Pennsylvania with lime neutralization of its acid headwaters; and the effects of an acid spill and a caustic spill in the Clinch River in Virginia. The recoveries depend on the severity and duration of the stress, the characteristics of the receiving stream, and the availability of organisms for recolonization. OR 71-88

MD71-24 HYDROLOGIC EFFECTS OF STRIP MINING WEST OF APPALACHIA

Cederstrom, D. J. (U.S. Geol. Surv.), Mining Congr. J. 57 (3), 46-50 (1971). The author points out that cast ground in surface-mined areas may have a greater storage potential for water than undisturbed ground because void space has been increased. He cites Corbett's study that shows that in flat or gently rolling terrain stream flow is sustained by drainage from surface-mined land. Methods of controlling acidity by care in disposing of pyritic material are also discussed. The hydrologic as well as aesthetic and economic advantages of lakes formed on surface-mined lands are noted. OR 71-15

MD71-25 VASCULAR AQUATIC PLANTS IN ACID MINE WATER OF THE MONONGAHELA RIVER, WEST VIRGINIA

Clarkson, R. B. and Moore, J. A., W. Va. Univ., Water Res. Inst., Bull. 2 (1971). 8 pp. Six areas on the Monongahela, Tygart Valley, and West Fork Rivers were studied

MD71-25 (continued)

intensively. Measurements were made of nitrogen, phosphate, calcium, total acidity, iron, and pH of the water; substrate grain size; water velocity; and water level. The authors conclude that "substrate, phosphate, and water-level fluctuation are the factors most important to growth of vascular aquatic plants in streams containing acid mine water." OR 71-2

MD71-26 CLEAN AIR AND WATER

Coal Mining Process. 8 (11), 65-66 (1971). The Kaiser Resources Ltd. program to minimize air and water pollution at their coal mining and processing operations at Sparwood, British Columbia, is described. OR 71-119

MD71-27 COAL, CONSOL AND THE ENVIRONMENT - A SPECIAL REPORT

Consol News 10 (1), (June 1971). 36 pp. Consolidation Coal Company's programs for air and water pollution abatement and control include projects at the Hanna Division, Mountaineer Div., Pittsburgh Coal Div., Blacksville Div., and the Truax Traer Division. OR 71-26

MD71-28 INFLUENCE OF ACID MINE WATER ON THE MICROFLORA OF SEWAGE

Cook, H. A. and Wilson, H. A., W. Va. Univ., Water Res. Inst., Bull. 3 (1971). 24 pp. This bulletin reports the data obtained: (a) from a study of the microflora of the acid mine water-domestic sewage polluted Monongahela River; (b) from a study of the effects of acid mine drainage on the microorganisms in domestic sewage; and (c) from a determination of the amino acids present in raw sewage which could serve as nutrients for the microflora in the receiving waters. Microscopic studies showed that low numbers of yeasts and filamentous fungi were present in near neutral sewage but when the sewage was mixed with acid mine water, or made equally acid with 6N H_2SO_4 upon incubation the predominating flora changed from bacteria to yeasts and filamentous fungi. Fifteen of the common amino acids were detected in raw sewage. When acid mine water was mixed with sewage, several of these amino acids could no longer be detected and some were only present in trace amounts. The ammonia concentration increased greatly in the sewage-acid mine water mixtures. (From authors' Introduction and abstract) OR 71-78

MD71-29 COOPERATIVE MINE DRAINAGE STUDY--SELECTED AREAS IN THE CLARION RIVER BASIN

EPA, Office of Water Programs, Wheeling, W. Va. (June 1971). 144 pp. + app. In 1967, the watershed areas of Toby Creek (Elk and Jefferson Counties), Deer Creek, Licking Creek, Mill Creek, Piney Creek, and Toby Creek (Clarion County) were inventoried for mine drainage discharges. The mine drainage sources are described by type and location and are also shown on watershed maps. Water quality analyses of specific discharges include pH, conductance, flow, acidity, alkalinity, hardness, total iron, and manganese. Similar water quality analyses are also given for designated stream sampling stations. Values from the water quality survey of 1966 are also included in the report. OR 71-62

MD71-30 STRIP-MINING, EROSION AND SEDIMENTATION

Curtis, W. R., Trans. ASAE 14 (3), 434-436 (1971). Weathering and erosion begin on the spoil bank as soon as the mining operation exposes the unconsolidated and unprotected material. The rate of weathering is faster in this freshly exposed material than in unmined areas. Generally, larger storms produce more sediment, but the maximum concentrations of sediment also depend on the area disturbed and whether mining is active. (From author's summary) OR 71-116

MD71-31 TERRACES REDUCE RUNOFF AND EROSION ON SURFACE-MINE BENCHES

Curtis, W. R., J. Soil Water Conserv. 26 (5), 198-199 (1971). A two-year study in Breathitt, Kentucky indicated that terraces can effectively control runoff and erosion on surface-mine benches. In an area where the spoil was predominantly shale, peak flows on a terraced plot averaged 65 percent less than on a control plot, sediment yield averaged 52 percent less and total runoff averaged 42 percent less. Comparable figures on a set of plots having substantial amounts of sandstone were 65, 70, and 6 percent respectively. Average storm runoff duration was 1 percent higher on the terraced plot of each pair. (Author's abstract) OR 71-117

MD71-32 VEGETATING STRIP-MINE SPOILS FOR RUNOFF AND EROSION CONTROL

Curtis, W. R. (Northeastern Forest Expt. Sta., USDA), Proc. Revegetation Econ. Use Surface Mined Land Mine Refuse Symp., Pipestem State Park, W. Va., Dec. 2-4, 1971. pp 40-41. The functions and methods of vegetating strip mine spoils are discussed generally. OR 71-118

MD71-33 NEUTRALIZATION OF FERROUS IRON-CONTAINING ACID WASTES

Cywin, A. (to United States of America, represented by the Secretary of the Interior), U.S. Pat. 3,617,559 (Nov. 2, 1971). 4 pp. Acid waste waters containing ferrous iron are neutralized using limestone in a finely divided state. Substantial amounts of a mixed valence, hydrous iron oxide sludge are recycled back to the neutralization and aeration steps of the process to produce a dense, easily dewatered sludge having improved handling characteristics. (Abstract of the disclosure) OR 71-109

MD71-34 NEUTRALIZATION OF FERROUS IRON-CONTAINING ACID WASTES

Cywin, A. and Mihok, E. A. (to United States of America represented by the Secretary of the Interior), U.S. Pat. 3,617,562 (Nov. 2, 1971). 5 pp. Ferrous iron-containing acid waste waters are neutralized to form a dense, compact, and easily settleable sludge. Ferrous to ferric iron ratios are adjusted prior to neutralization by catalytic oxidation to conform approximately to that of magnetite: 1 Fe^{++} to 2 Fe^{+++}. Neutralization of the acid waste and precipitation of a mixed valence iron oxide is accomplished using a finely divided limestone slurry as the preferred neutralizing agent. (Abstract of the disclosure) OR 71-108

MD71-35 FINAL REPORT: EXPERIMENTAL RESEARCH PROJECT IN THE TREATMENT OF MINE DRAINAGE - HARWICK MINE OF DUQUESNE LIGHT COMPANY MONARCH SHAFT - INDIANA TOWNSHIP ALLEGHENY COUNTY, PENNSYLVANIA

Darkes, W. F., Jr., Charmbury, H. B., and Maneval, D. R., Pa. Dept. Mines Miner. Ind., Jan. 1971. 20 pp. The purpose of the project was to reduce the iron in the water discharged from the mine to Little Deer Creek. Water in the mine pool was aerated and treated with basic materials to precipitate the iron as ferric hydroxide. Lime, lime slurry, and 50 percent sodium hydroxide solution were used separately. Results of analyses of the mine water for iron showed that untreated water averaged 62 ppm, water treated with lime slurry averaged 35 ppm, and water treated with sodium hydroxide solution averaged 44 ppm. The pH of water in pool during treatment averaged 6.5. The time for a dye injected into the pool to be discharged into the receiving creek was also noted. It is suggested that iron was not reduced more than 50 percent because additional water flowed into the treated pool from adjacent areas of the mine. OR 71-3

MD71-36 ACID MINE DRAINAGE ABATEMENT PROGRAMS IN SURFACE MINING

Deane, J. A. (Peabody Coal Co.), Acid Mine Drainage Workshop, Athens, Ohio, by Ohio Univ., 1971. 4 pp. Abatement methods used by Peabody Coal Company in surface mining in the rolling terrain of the midwest are described. The author credits control measures advocated in ORSANCO Resolution 5-60 and in "Principles and Guide to Practices in the Control of Acid-Mine Drainage" as being the basis for good abatement programs. OR 71-46

MD71-37 COSTS AND EFFECTS OF A WATER QUALITY PROGRAM FOR A SMALL STRIP MINING COMPANY

Dreese, G. R. (1) and Bryant, H. L. (2) [(1) W. Va. Univ. and (2) Xavier Univ.], Rept. to U.S. Army Engineers Institute for Water Resources, IWR Rept. 71-77 (1971). 150 pp. Several years of operation of an actual mining firm in southeastern Ohio were analyzed to determine how the costs of pollution control (land reclamation and mine drainage treatment) would affect its financial situation. The firm, whose identity is disguised in the report, is a small marginal producer in an area dominated by a larger producer. The study concludes that costs of pollution control for small producers could force them out of business unless the price of coal increases so that these costs can be passed on to the user. OR 71-63

MD71-38 PRELIMINARY REPORT OF WATER QUALITY MEASUREMENTS AND REVEGETATION TRIALS ON MINED LAND AT LUSCAR, ALBERTA

Etter, H. M., Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alberta, Internal Rept. NOR-3, Aug. 1971. 19 pp. This report concerns a project around the Camp, Cabin, and Luscar Creeks in the Upper Foothills of western Alberta, Canada. The project involved water sampling and testing in addition to a revegetation by hydroseeding on weathered sandstone and shale overburden. Five seed mixtures were used and a tabulation gives the grasses and legumes and their maximum expected number of germinants. Several sketches and diagrams show the location and position of the test areas. A detailed tabulation of the water sample analyses is also given. Sediment, including coal particles, was also monitored. OR 71-107

MD71-39 EVALUATION OF A NEW ACID MINE DRAINAGE TREATMENT PROCESS

Black, Sivalls & Bryson, Inc., Rept. to EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 DYI 02/71 (1971). 155 pp. An economic and engineering evaluation of a submerged coal refuse combustion process to convert acid mine water (AMW) to potable water has been made. In this process coal refuse is burned in molten iron to supply energy for distillation or reverse osmosis, and the coal refuse sulfur is trapped in a slag for eventual recovery of sulfur. Laboratory experimentation on slags indicated that sulfur is obtained, high slag sulfur partition ratios are achieved, fluid slags are produced, and that desulfurized slags are not suitable for neutralization. (From authors' abstract) OR 71-25

MD71-40 DETECTION OF ABANDONED UNDERGROUND COAL MINES BY GEOPHYSICAL METHODS

Fisher, W., Jr. (HRB-Singer, Inc., Environ. Sci. Br.), Rept. to EPA and Pa. Dept. Environ. Resour., Water Pollut. Contr. Res. Ser. 14010 EHN 04/71 (1971). 94 pp. NTIS, PB-211 554. Electrical resistivity, self-potential, infrared radiometry, total field and differential magnetometry, seismic refraction and reflection, very low frequency electromagnetic and induced polarization over well documented, drift, coal mines were evaluated in field studies. Airborne infrared radiometry proved to be an excellent tool for detecting and mapping acid mine/fresh water sources, acid mine/fresh water drainage, and fracture traces under selected conditions. Resistivity and magnetics anomalies coincide with some (not all) drift mine entries. Induced polarization data shows some apparent correlations with mine workings. Other methods tested did not yield correlatable information. There are 90 references. (From author's abstract) OR 71-75

MD71-41 ACIDITY CONTROL IN BALD EAGLE CREEK AND WEST BRANCH SUSQUEHANNA RIVER, CLINTON COUNTY, PENNSYLVANIA

Flippo, H. N., Jr., U.S. Geol. Surv., Water Resour. Div., Harrisburg, Pa., Open-File Rept., Feb. 1971. 28 pp. Regression analysis of chemical and physical data collected on Beech Creek resulted in two curves that relate the concentration of free hydrogen ion to the electrical specific conductance of the water, providing a means of estimating, through use of data telemetered from a water-quality monitor on Beech Creek, the acid load in the stream at any time. These estimates will enable the operators of Foster Joseph Sayers Dam on Bald Eagle Creek to release

MD71-41 (continued)

sufficient alkaline water from the reservoir to prevent fish kills that could be caused by the acid from Beech Creek. Some water in the reservoir may be used for improving the quality of the West Branch when the river is unusually acid. (From author's abstract) OR 71-84

MD71-42 STUDIES ON LIMESTONE TREATMENT OF ACID MINE DRAINAGE. PART II

Ford, C. T., Boyer, J. F., and Glenn, R. A., Bituminous Coal Research, Inc., Rept. to EPA, Office Res. Monit., Water Pollut. Contr. Res. Ser. 14010 EIZ 12/71 (1971). 140 pp. NTIS, PB-195 282. Laboratory studies were conducted with limestone as the neutralizing agent for coal mine water. Batch tests were used to determine the properties of limestone necessary for effective neutralization. Continuous flow tests were used to determine conditions required for an effective neutralization process. The following variables are of importance for limestone to be an effective neutralizing agent: (a) particle size, (b) Ca and Mg content, and (c) surface area. Limestones having the smallest particle size commercially available were tested and found to be effective if criteria for variables other than particle size were met. Data obtained with a small laboratory continuous flow test apparatus were used in determining operating conditions for a continuous treatment process for neutralizing mine water with limestone. An evaluation of this process indicated technical feasibility, advantages and disadvantages, and need for further study of certain aspects of this process. The cost of treating coal mine water with the BCR limestone treatment process compares favorably with the published costs of treating mine water by other processes. (Authors' abstract) OR 71-68

MD71-43 DEEP MINE SEALING

Foreman, J. W. (Gwin, Dobson & Foreman, Inc.), Acid Mine Drainage Workshop, Athens, Ohio, by Ohio Univ., 1971. 27 pp. Both early and more recent experiences with mine sealing are reviewed. Mining conditions which affect different types of seals and their successful use are discussed. Diagrams and photographs illustrating the seals and their uses are included. OR 71-47

MD71-44 STATEMENT

Garvey, J. R. (Bitum. Coal Res., Inc.), Conf. on Pollut. of Monongahela River and Its Tributaries, Pittsburgh, Pa., by EPA, 1971. 5 pp. In his statement, Mr. Garvey comments on and reacts to the Recommendations to the Conference by the Technical Committee. OR 71-42

MD71-45 ACID MINE DRAINAGE ABATEMENT IN OHIO

Gebhart, E. J. (Ohio Div. Forestry Reclamation), Acid Mine Drainage Workshop, Athens, Ohio, by Ohio Univ., 1971. 7 pp. In this keynote address of the conference, the acid mine drainage pollution in Ohio is described and work toward alleviating the problem is summarized. OR 71-48

MD71-46 THE LEGAL FRAMEWORK OF ACID MINE DRAINAGE CONTROL

Goldberg, E. F. (Univ. Md. School of Law), Acid Mine Drainage Workshop, Athens, Ohio, by Ohio Univ., 1971. 18 pp. Laws relating to water quality control and to surface mining regulation in coal mining states are discussed. The constitutional problems involved in reclaiming stripped areas by governmental bodies are pointed out. There are 35 references. OR 71-49

MD71-47 MINE DRAINAGE POLLUTION ABATEMENT SURVEY, PIERSONS RUN WATERSHED - ALLEGHENY COUNTY, PENNSYLVANIA

Gray, R. E., General Analytics, Inc., Rept. to Pa. Dept. Environ. Resour., Proj. SL-157 (Sept. 20, 1971). 20 pp. + app. The results both of the field survey of the watershed and of a search to obtain all available data on mining operations in the area are presented. The headwaters of the stream are within Allegheny County Regional Park No. 3 (Boyce Park) and the stream drains much of the park lands.

MD71-47 (continued)

There are several sources of acid drainage into the stream within the park. Water sampling was carried out at 21 points and values are given for pH, flow, sulfate, total iron, acidity, and alkalinity. Recommendations for abatement include backfilling stripped areas, filling sink holes into deep mines, sealing of a small mine opening which has a low volume of discharge, fly ash injection to alter deep mine flow, and a lime treatment plant. OR 71-89

MD71-48 MINE SPOIL POTENTIALS FOR WATER QUALITY AND CONTROLLED EROSION

Grube, W. E., Jr., Jencks, E. M., Singh, R. N., Smith, R. M., and Wilson, H. A., Div. Plant Sci. College Agr. Forestry, W. Va. Univ., Rept. to EPA, OWP Water Pollut. Contr. Res. Ser. 14010 EJE 12/71 (1971). 206 pp. NTIS, PB-208 817. Coal overburden materials were characterized by standard techniques for coal, rock, and soil analysis. With this knowledge, operators and reclaimers can handle spoil so that acid production and water pollution are minimized and revegetation is encouraged. OR 71-72

MD71-49 WATER TREATMENT - A WAY TO BREAK MININGS' POLLUTION CYCLE

Hall, E. P. and Cywin, A. (EPA, Water Quality Res.), AIME Environ. Quality Conf., Washington, D. C., 1971. 13 pp. The authors review EPA sponsored projects on abatement of acid mine drainage pollution. OR 71-19

MD71-50 FOAM SEPARATION OF ACID MINE DRAINAGE

Hanson, P. J., Horizons Inc., Rept. to EPA, Water Pollut. Contr. Res. Serv. 14010 FUI 10/71 (1971). 59 pp. NTIS, PB-208 411. Laboratory studies of continuous flow foam separation were conducted to determine the optimum operating conditions for maximum extraction of dissolved metal cations (Fe, Ca, Mg, Mn and Al) from acid mine drainage. The effects of Ph, chelate addition, surfactant type and concentration, air sparging rate, metal concentration and foam drainage were investigated. The average extraction rate obtained was 1.9 x 10^{-7} moles total metal per cm^2 column cross-section area per minute. Operation in simple and countercurrent foaming modes produced similar extraction rates for acid mine drainage. The low extraction capacity of foam fractionation renders the process economically unfeasible for the treatment of acid mine drainage. Surfactant regeneration from collapsed foam by the addition of base was investigated as a means for surfactant reuse and cost reduction. (From author's abstract) OR 71-73

MD71-51 RESTORATION OF A TERRESTRIAL ENVIRONMENT - THE SURFACE MINE

Hill, R. D. (Robt. A. Taft Water Res. Center, Cincinnati, Ohio), Presented, Assoc. Southeastern Biologists, Richmond, Va., April 16, 1971. 22 pp. The ASB Bull. 18 (3), 107-116 (1971). (EPA, WQO Publ. No. 14010 04/71). Techniques of surface mining that minimize damage to land control water pollution, and facilitate reclamation are described. OR 71-11

MD71-52 LIMESTONE TREATMENT OF ACID MINE DRAINAGE

Hill, R. D. (1) and Wilmoth, R. C. (2) [(1) EPA, Cincinnati, Ohio and (2) EPA, Norton, W. Va.], Trans. AIME 250, 162-166 (1971). This paper was presented at the SME Fall meeting, St. Louis, Mo., 1970. OR 71-54

MD71-53 NEUTROLOSIS TREATMENT OF ACID MINE DRAINAGE

Hill, R. D. (1), Wilmoth, R. C. (2), and Scott, R. B. (2) [(1) Robt. A. Taft Water Res. Center, Cincinnati, Ohio and (2) Norton Mine Drainage Field Site, Norton, W. Va.], 26th Ann. Purdue Ind. Waste Conf., Lafayette, Ind., 1971. 13 pp. EPA, WQO Publ. No. 14010 05/71. The process consists of operation of reverse osmosis unit at maximum recovery, neutralization of brine to pH 4.3 - 4.5, and recycle of neutralized brine water to the reverse osmosis unit. Overall results of more than 98 percent water recovery and less than 2 percent sludge were obtained. The raw mine

MD71-53 (continued)

drainage used in this study is characterized by total iron of about 100 ppm with high ferric to ferrous ratio, and acidity of 600 ppm as $CaCO_3$. The reverse osmosis equipment had a rated capacity of 10,000 gpd. Membrane fouling was reduced by flushing. Summary analyses of raw water, blended feed, brine, and product water are tabulated. OR 71-17

MD71-54 ION-EXCHANGE SYSTEM BOASTS MORE PULLING POWER

Kunin, R. and Downing, D. G. (Rohm and Haas Co.), Chem. Eng. 78 (15), 67-69 (1971). The Desal ion exchange process and its application to acid mine drainage treatment is described. A process flowsheet is included. OR 71-30

MD71-55 LACKAWANNA RIVER MINE DRAINAGE POLLUTION ABATEMENT PROJECT PART I

Albert E. Peters Associates, Rept. to Pa. Dept. Environ. Resour., Proj. SL-139 (Nov. 30, 1971). 37 pp. + app. The study area of the upper Lackawanna River watershed is in portions of Susquehanna, Wayne, and Lackawanna Counties and includes approximately 8.2 miles of the river. Both field and laboratory results of water testing from 55 sampling locations are reported. The testing was carried out over a period of 18 months from 1969 into 1971. Values are tabulated for flow, pH, acidity, alkalinity, total iron, and sulfates. Specific means of redirecting both surface and underground flow to minimize acid drainage into the river are recommended as abatement measures and a neutralization plant is not considered necessary. The general abatement plan is divided into separate projects which are given an order of priority. A general cost estimate is presented for each project. OR 71-91

MD71-56 CARBONATE BONDING OF COAL REFUSE

LaRosa, P. J., Karnavas, J. A., and Pelczarski, E. A., Black, Sivalls & Bryson, Inc., Rept. to U.S. EPA, Water Qual. Office, Water Pollut. Contr. Res. Ser. 14010 FOA 02/71 (1971). 44 pp. NTIS, PB-198 230. A laboratory study of the operating variables which affect the properties of carbonate bonded coal refuse has been made. The carbonate bonding process utilizing coal refuse as a fill material consists of mixing coal refuse with water and lime hydrate, compacting the mixture, and reacting it with a carbon-dioxide-rich gas to form a coherent structure bonded by a matrix of calcite crystals. The resulting carbonate bonded coal refuse can be used in road building or as a coal refuse pile sealant to minimize acid mine water pollution. (From authors' abstract) OR 71-98

MD71-57 STUDY OF SULFUR RECOVERY FROM COAL REFUSE

LaRosa, P. J. and Michaels, H. J., Black, Sivalls & Bryson, Inc., Rept. to EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 FYY 09/71 (1971). 67 pp. NTIS, PB-203 488. A feasibility study has been performed on a process producing sulfur from the refuse from coal preparation. In this process, limestone and coal refuse are ground, pelletized and preheated before entering a desulfurizing shaft reactor where a hard, fired ash pellet and an H_2S-SO_2 bearing offgas are produced. After sulfur, tar, and other gases are removed, the resulting H_2S-SO_2 gas proceeds to a conventional sulfur recovery plant. The economic evaluation of the bench scale laboratory results shows that the process is a feasible, and in some cases profitable, means of abating water pollution due to rainfall percolating through high sulfur coal refuse. (Authors' abstract adapted) OR 71-59

MD71-58 LIMESTONE TREATMENT OF COAL MINE DRAINAGE

Lovell, H. L. (Dir., Mine Drainage Res. Sec., Pa. State Univ.), Mining Congr. J. 57 (10), 28-34 (1971). Theoretical considerations of acid mine drainage neutralization, with emphasis on the use of limestone are discussed. Some experience operating the treatment plant at Hollywood, Pennsylvania is described, and advantages and disadvantages are listed. A tentative conclusion is that for successful treatment, if ferrous iron is present at a concentration greater than 500 mg/l, it should be oxidized before limestone neutralization. OR 71-93

MD71-59 LIMESTONE TREATMENT OF COAL MINE DRAINAGE - AN APPRAISAL OF PROCESS CAPABILITIES AND PARAMETERS

Lovell, H. L. (The Pa. State Univ.), Am. Mining Congr. Meet., Pittsburgh, Pa., 1971. 20 pp. The limestone reactor of the mine drainage treatment facility at Hollywood, Pennsylvania and its operating parameters are described and discussed in the light of theoretical considerations of limestone neutralization of acid mine drainage. The conclusion from accumulated experience is that the lower the concentration of ferrous iron in the drainage water, the more effective the treatment. Oxidation of ferrous iron before neutralization is advantageous. OR 71-27

MD71-60 INORGANIC SULFUR OXIDATION BY IRON-OXIDIZING BACTERIA

Lundgren, D. G., Syracuse Univ., Rept. to EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 DAY 06/71 (1971). 149 pp. NTIS, PB-213 006. This study of the microbes which are a cause of mine drainage pollution is reported and discussed under four separate topics. The three sections concerned with *Thiobacillus ferrooxidans* are studies of sulfur metabolism, studies of iron metabolism, and heterotrophic growth under acid conditions. The fourth section reports the isolation and characterization of a new *Thiobacillus* species from alkaline mine drainage. There are 98 references. OR 71-64

MD71-61 WATER QUALITY MANAGEMENT IN THE MONONGAHELA RIVER BASIN

Lyon, W. A. (Dir., Bur. Sanit. Eng., Pa. Dept. Environ. Resour.), Conf. on Pollut. of Monongahela River & Its Tributaries, Pittsburgh, Pa., by EPA, 1971. 102 pp. The information presented by Pennsylvania in 1963 on water quality and pollution control in its portion of the Monongahela River Basin is updated. Sources of pollution and action on each are listed by county and according to status as industrial waste, sewage, or drainage from deep or surface mines. OR 71-41

MD71-62 MINE DRAINAGE AND ACID WATER TREATMENT

Coal Age *76* (7), 186-192 (1971). Water handling to minimize acid mine drainage formation and neutralization of acid water that does form are emphasized in this practical guide to mine drainage pollution abatement. OR 71-28

MD71-63 MINE DRAINAGE REPORT TO CONFEREES

Enforcement Conf., Monongahela River & Its Tributaries, Pittsburgh, Pa., by EPA, 1971. 22 pp. This report reviews the call to the first session of the Conference held December 17-18, 1963 at Pittsburgh, Pennsylvania. The conclusions and recommendations of the 1963 Conferees are stated. Recommendation No. 4 advised the establishment of a Technical Committee charged with determining the amount of pollution of the Monongahela River Basin due to mining and with developing a remedial program including cost estimates. The data developed by the Technical Committee in carrying out its purposes are summarized. The seven recommendations submitted by the Technical Committee to the 1971 session are included. A brief review of legal problems encountered in implementing abatement procedures is also presented. OR 71-39

MD71-64 MINE REFUSE PILE COVERINGS TO REDUCE WATER PERCOLATION

MSA Res. Corp., Sum. Rept. to Pa. Environ. Resour. Admin., 1971. 32 pp. The characteristics and costs of a number of materials which could be used as mine waste pile covers are discussed. Urethane foam, polyethylene sheeting, linseed oil, fly ash, and polyvinyl chloride cocooning material were tested under conditions simulating use. Urethane foam and polyethylene sheeting did not deteriorate during the 15 month test period or during an additional 15 month period. Pile characteristics and site preparation are also discussed. There are 38 references. OR 71-8

MD71-65 MONONGAHELA RIVER MINE DRAINAGE REMEDIAL PROJECT

U.S. EPA, Div. Field Invest., Cincinnati, Summary Rept. to Enforcement Conf., Monongahela River & Its Tributaries, 1971. 235 pp. The material presented in Mine Drainage Report to Conferees is included here substantially without change. In addition there are detailed sections on the geology and hydrology of the Monongahela River Basin; mining methods; effects of mine drainage on stream quality; the stream sampling program carried out by the Technical Committee; cost estimates for pollution abatement; and the regulations and abatement programs of Maryland, Pennsylvania, and West Virginia. Attachment A gives summaries of inventories of pollution sources by sub-basin. In Attachment B are recommendations of individual Technical Committee members. Attachment C gives the status of active mines including effluent quality data. OR 71-40

MD71-66 ACID MINE DRAINAGE: A MATHEMATICAL MODEL

Morth, A. H., Ph.D. Thesis, The Ohio State Univ., 1971. 165 pp. A mathematical model has been developed which can be used to describe the drainage flow rates and acid loads from a drift mine. The McDaniels Test Mine was used to develop this model. The model's predictions of acid load and drainage flows match existing data within twenty percent on a monthly basis and within five percent on an annual basis. The model has been used to generate predictions of acid loads from McDaniels Mine for future years under varying levels of precipitation and different concentrations of oxygen in the mine atmosphere. The computer program used in developing the model is given in detail. (Adapted from author's summary and conclusions) OR 71-22

MD71-67 DEWATERING OF MINE DRAINAGE SLUDGE

Moss, E. A., Coal Res. Bur., W. Va. Univ., Rept. to EPA, Water Pollut. Contr. Res. Ser. 14010 FJX 12/71 (1971). 90 pp. NTIS, PB-208 347. This report is a literature review on thickening and dewatering of sludge resulting from lime or limestone neutralization of coal mine drainage. The effects of mine water constituents and methods of treatment on the physical and chemical characteristics of the resulting sludge are described. Such current practices as aeration, recirculation, and neutralization are discussed. Additional techniques at various stages of development, such as thickening, conditioning, and dewatering are evaluated for use in coal mine drainage treatment. The most promising coal mine sludge dewatering technique appears to be vacuum filtration. Other methods such as sand bed filtration, pressure filtration and centrifugation may also be applicable. Recommendations are made as to the areas in coal mine drainage treatment and sludge densification that need further research. (Author's abstract) OR 71-67

MD71-68 NEUTRADESULFATING TREATMENT PROCESS FOR ACID MINE DRAINAGE

Catalytic, Inc., Rept. to EPA, Water Pollut. Contr. Res. Ser. ORD-14010 DYH 12/71 (1971). 102 pp. NTIS, PB-213 720. The raw water is neutralized with sodium bicarbonate to precipitate iron and aluminum, followed by cation exchange to remove sulfate. Barium is eluted from the exchange resin and reacts with sulfate in the water to form a precipitate. Barium is recovered from the precipitate and is processed to recharge the exchange resin. The water is further treated to remove hydrogen sulfide by conversion to sulfur as a saleable product. The project was terminated at the end of Phase I due to the high estimated cost of treatment. (Author's abstract adapted) OR 71-71

MD71-69 PREVENTION OF COAL MINE DRAINAGE FORMATION BY WELL DEWATERING

Parizek, R. R., Pa. State Univ., Spec. Res. Rept. SR-82 to Pa. Dept. Environ. Resour., April 15, 1971. 73 pp. Large quantities of ground-water may be encountered in deep coal mines which must be treated to meet water-quality standards before being discharged. Source beds supplying leakage to deep mines may be dewatered during and after mining under favorable hydrogeologic conditions to prevent pollution, thereby minimizing treatment costs and improving working conditions. Requisite hydrogeologic

MD71-69 (continued)

data to determine the feasibility of dewatering may be obtained during the coal exploration program provided that both hydrogeologic and coal exploration programs are planned in advance and coordinated. Studies, including costs, for two hypothetical mines are presented. (From author's Summation of Results) OR 71-105

MD71-70 PILOT SCALE STUDY OF ACID MINE DRAINAGE

The Ohio State Univ., Res. Found., Rept. to EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 EXA 03/71 (1971). 84 pp. PB-214 771. A research facility has been developed to study pyrite oxidation and the resulting acid mine drainage on a pilot scale basis. The test units include a small, long-abandoned drift mine (the McDaniels Mine), and six 33-inch diameter auger holes, drilled for the express purpose of furnishing comparable, isolated, experimental units. The effect of oxygen concentration on acid production has been studied in the McDaniels mine. The response time of the mine to imposed mine atmospheres of varying oxygen concentrations, mine drainage data, and information derived from boreholes through the overburden around the mine, provide the basis for describing sites of pyrite oxidation and the significance of bacterial catalysis on oxidation rate. Results to date indicate that the major reaction sites are located above the ground water table where gas, rather than liquid, is the continuous phase. There is no indication of significant bacterial catalysis of pyrite oxidation. (From authors' abstract) OR 71-36

MD71-71 PROCEEDINGS OF ACID MINE DRAINAGE WORKSHOP

Athens, Ohio, by Ohio Univ., Aug. 2-6, 1971. 167 pp. These complete proceedings of a workshop organized in cooperation with EPA, ORSANCO, Ohio Reclamation Assoc., CIAC-ORSANCO, and Ohio Dept. of Natural Resources were compiled by Moid U. Ahmad. In addition to papers already abstracted, there are presentations at, or summaries of, four separate workshops held on August 5, 1971. Option 1, a field trip included visits to (a) Leading Creek Watershed for a demonstration of erosion and erosion control led by Heber Lessig of U.S. Soil Conservation Service; (b) Lake Hope water quality monitoring network led by David Papier of Ohio Dept. Natural Resources; (c) McDaniel Demonstration Mine of Ohio State Univ. led by K. S. Shumate; (d) successful reclamation project of Wayne National Forest Service led by Paul Brohn; and (e) Glen Ebon acid producing areas including a presentation of the thermal infrared photographic study of Professor Ahmad and Bobba Ghosh of Ohio Univ. and John Antalovich of Kucera and Assoc., Inc. Option 2 included two presentations of the topic "Physical and chemical analyses of mine water." Howard Latz of Ohio Univ. discussed "Chemical analysis of mine water" and conducted a laboratory session in which analyses were carried out by colorimetry, by flame emission and by atomic absorption. "Mine drainage monitoring" was the topic presented by Ronald D. Hill, Chief, Mine Drainage Pollution Control Activities, Office of Research and Monitoring, EPA. Option 3, "Identification of pyrite in rocks" was presented by Russell A. Brant of ORSANCO. In Option 4, three papers on "Spoil bank chemistry and its relation to plant growth" were given by W. E. Grube, Jr., E. M. Jencks, R. N. Singh, and R. M. Smith. The verbatim report of the panel discussion summarizing the workshop is also included in the proceedings. OR 71-96

MD71-72 PROCEEDINGS OF THE CONFERENCE IN THE MATTER OF POLLUTION OF THE INTERSTATE WATERS OF THE OHIO RIVER AND ITS TRIBUTARIES IN THE WHEELING, WEST VIRGINIA AREA (OHIO-WEST VIRGINIA)

Wheeling, W. Va., by U.S. EPA, Oct. 13, 1971. 385 pp. EPA, under the provisions of the Water Pollution Control Act, amended, called Ohio, West Virginia, and Ohio River Valley Water Sanitation Commission to confer on the condition of the Ohio River in the 36 miles from Toronto, Ohio to McMechen, West Virginia. Although municipal pollution and general industrial pollution are emphasized, acid mine drainage is acknowledged as being part of the problem. The report includes the verbatim account of the public session and the conclusions and recommendations for pollution abatement from the conferees' session. OR 71-100

MD71-73 PROCEEDINGS - SECOND SESSION OF THE CONFERENCE IN THE MATTER OF POLLUTION OF THE INTERSTATE WATERS OF THE MONONGAHELA RIVER AND ITS TRIBUTARIES

Pittsburgh, Pa., by EPA, Pennsylvania, West Virginia, and Maryland, August 24, 1971. 264 pp.+ This verbatim transcript gives statements, presentations and discussions at the Conference as well as material requested later to be entered into the record. OR 71-87

MD71-74 PURIFICATION OF MINE WATER BY FREEZING

Applied Sci. Lab., Inc., Rept. to Pa. Dept. Mines Miner. Ind. and EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 DRZ 02/71 (1971). 61 pp. NTIS, PB-213 121. Of the five freezing methods investigated, the use of a bayonet type heat exchanger was judged most satisfactory and was the method used in the tests. Ice deposited on the heat exchanger was melted in three steps and the product water of each step was evaluated. Innermost layers of ice always showed most reduction in impurities, up to 98 percent with some runs. The concentration of impurities in the layers of ice is not greatly affected by the percent conversion to ice. Partial freezing experiments were also carried out on acid mine water which had been treated with lime and had a low amount of iron and aluminum. Product water showed good reduction of calcium, magnesium, and manganese, but poor reduction of sulfate. The apparent poor sulfate reduction was in contrast to excellent sulfate reduction in experiments with raw mine water and with ferrous ammonium sulfate solution. An interference in the colorimetric analysis for sulfate is suggested as the reason. Appendixes include information on the various freezing methods investigated; the analytical data; and a bibliography with abstracts. OR 71-4

MD71-75 QUICK SOLUTION TO PROBLEM OF ACID MINE DRAINAGE

Mining Eng. 23 (10), 42 (1971). This note describes the handling of a clean water discharge at Jones & Laughlin Steel Corp.'s Vesta #5 coal mine that suddenly turned acid and "bright red." The discharge was diverted to a surface pond for settling and acid drainage in the mine was diverted to a borehole where there was a treatment plant to neutralize the acid. OR 71-94

MD71-76 BIOLOGICAL TREATMENT OF ACID MINE WATER

Rabolini, F. and Rice, P. A., Syracuse Univ., Final Rept. to EPA, FWQA, Grant No. WP-01460-01 (July 1971). 77 pp. A detailed picture of the growth of sulfate-reducing bacteria is given and the feasibility of treating acid mine water biologically with sulfate-reducing bacteria was tested. Actual acid mine water can be treated biochemically with sulfate-reducing bacteria. The sulfate reduction rate was found to be proportional to the product of the organic substrate and bacteria concentrations. Temperature and pH affected the rate, with no growth observed at a reactor pH of 5.5 or below. Sodium lactate was the most effective substrate used, but its cost is too high for industrial application. Digester overflow sludge was successfully used as an organic substrate and has the advantage of partially neutralizing the acid mine water. (Authors' conclusions adapted) OR 71-77

MD71-77 RECOMMENDATIONS - MONONGAHELA ENFORCEMENT CONFERENCE

Conf. on Pollut. of Monongahela River and Its Tributaries, Pittsburgh, Pa., (1971). 2 pp. These are the 9 recommendations from the Conferees at the session of the Conference held on August 24 and 25, 1971. It is recommended that the Appalachian Regional Commission cooperate with the Environmental Protection Agency in setting abatement priorities and working toward their accomplishment; that EPA finance a study of legal problems rising from abatement and control of water pollution from mining; and that September 1, 1972 be set as the deadline for adoption of a nation-wide policy by EPA to include discharge from active mines in its standards program. The three recommendations from the Federal Conferees are concerned with abatement of pollution by mine operators and with being informed by reports from

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the states about the status of mines and abatement plans for mining discharges. Quarterly meetings of the Conferees until September 1, 1972 are also recommended. OR 71-43

MD71-78 THE EFFECTS OF VARIOUS GAS ATMOSPHERES ON THE OXIDATION OF COAL MINE PYRITES

Robins, J. D. and Troy, J. C., Cyrus Wm. Rice Div. NUS Corp., Rept. to EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 ECC 08/71 (1971). 140 pp. NTIS, PB-203 679. A number of experiments up to 150 days in length were conducted to study the acid production rate of coal mine pyrites under various gas atmospheres. The gas atmospheres studied were air, nitrogen, methane, and carbon dioxide. The lower limits of the oxidation process were studied by introducing small amounts of oxygen along with the inert blanketing gas and by studying the effects of deaerated versus air saturated feedwater. Acid production was found to be proportional to the available oxygen partial pressure. The acid parameters monitored continued to change and had not completely reached a steady state by the termination of the work. The acid production of nitrogen blanketed pyrite decreased to less than 1 percent of that of identical columns under an air atmosphere. Nitrogen and methane gases were equally effective in reducing acid production. Both of gases were slightly more effective than carbon dioxide. A large amount of detailed experimental data is presented. (Authors' abstract) OR 71-58

MD71-79 EVALUATION OF SHAVERS FORK MINE SEALS

Scott, R. B. (Norton Mine Drainage Field Site), EPA, WQO Publ. No. 14010--09/71 (1971). 14 pp. + app. Because of a fish kill in the U.S. Bureau of Sport Fisheries and Wildlife hatchery at Bowden, West Virginia, in 1966, a mine sealing program was undertaken on all known abandoned deep mines discharging acid into three tributaries of Shavers Fork. The appendix contains water quality data collected intermittently over four years to check the effectiveness of the seals. Values are recorded for temperature, flow in GPM, pH, acidity, calcium, magnesium, total hardness, sulfate, total iron, conductance, aluminum, and alkalinity as $CaCO_3$. Results of the monitoring program indicated that sealing had not significantly reduced the pollution load. OR 71-61

MD71-80 SILICATE TREATMENT FOR ACID MINE DRAINAGE PREVENTION

Tyco Lab., Inc., Rept. to EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 DLI 02/71 (1971). 94 pp. A laboratory study was carried out on actual mine refuse to evaluate the effectiveness of silicate based gels to prevent acid drainage from coal mine refuse piles. Alumina-silica gel applied so that the gel penetrated the pile up to 6 inches was most effective. Acid drainage formation was retarded by neutralization by the treatment materials as well as by coating of the pyritic refuse. However, treatment of acid mine water by sodium silicate and sodium aluminate was no more effective than conventional lime treatment. Although weathering tests showed that the gels were affected by extremes of temperature, washings of weathered test materials showed that residual alumina and silica maintained effectiveness for an equivalent of 120 inches rainfall. OR 71-9

MD71-81 ACID MINE WASTE TREATMENT USING REVERSE OSMOSIS

Sleigh, J. H. and Kremen, S. S., Gulf Environ. Systems Co., Rept. to EPA, WQO, Water Pollut. Contr. Res. Ser. 14010 DYG 08/71 (1971). 83 pp. Two reverse osmosis test units were operated during the course of these tests; a nominal 10,000-gpd unit equipped with eighteen 50-ft^2 modules and a nominal 4,000-gpd unit equipped with nine 50-ft^2 modules. The modules used in these units consisted of both high-selectivity and high-flux cellulose acetate membranes. The test program was carried out at three different mine drainage sites. The mine drainage water at the first site, Norton, West Virginia, contained greater than 98 percent of the iron

MD71-81 (continued)

present in the ferric form; at the other two sites, Morgantown, West Virginia, and Ebensburg, Pennsylvania, the drainage water contained predominantly ferrous iron. Discharges at the second site were so concentrated that recoveries were limited to 50 percent; recoveries of 80 to 90 percent were attained at the first and third sites. No iron fouling was encountered at any of the three sites. Specific salt rejections were greater than 97 percent at all sites. (From authors' abstract). OR 71-34

MD71-82 ACID MINE POLLUTION EFFECTS ON LAKE BIOLOGY

Smith, R. W. and Frey, D. G., Ind. Univ., Water Resour. Res. Cent., Rept. to U.S. EPA, Water Pollut. Contr. Res. Ser. 18050 EEC 12/71 (1971). 131 pp. NTIS, PB-210 709. Six coal surface-mine lakes in Pike County, southern Indiana ranging in pH from 2.5 to 8.2 were studied from July 1969 to December 1970. Results of sampling program for physical and chemical parameters and for biological parameters are reported. Generally, differences between the lakes indicated successional trends with increasing pH. OR 71-99

MD71-83 RATE OF PYRITE OXIDATION AND ACID PRODUCTION RATE IN THE FIELD

Smith, E. E. and Shumate, K. S. (The Ohio State Univ.), Acid Mine Drainage Workshop, Athens, Ohio, by Ohio Univ., 1971. 11 pp. Pyritic oxidation systems are described and illustrated by the formation of acid mine drainage in an underground mine. Application of this knowledge to abatement of mine drainage pollution under various conditions of mining is summarized. OR 71-50

MD71-84 SODA ASH TREATS PA. MINE DRAINAGE

Mining Eng. 23 (10), 42 (1971). This is a brief description of the use of soda ash to counter a massive acid flow into the West Branch of the Susquehanna River. OR 71-95

MD71-85 REDUCTION OF HYDROUS FERRIC OXIDE TO A MAGNETIC FORM WITH SODIUM DITHIONITE; IMPLICATIONS FOR COAL MINE DRAINAGE TREATMENT

Streeter, R. C., III (Bituminous Coal Res., Inc.), Ph.D. Thesis, The Pa. State Univ., 1971. 210 pp. Reaction variables studied included temperature, pH, initial iron concentration, mode of dithionite addition, effect of dissolved oxygen, and interferences due to the presence of dissolved calcium. The most strongly magnetic, densest, and fastest settling reaction products were obtained near pH 10, at temperatures of 80°C or above, and in the absence of dissolved oxygen and other impurities such as aluminum and calcium. Based on data from experiments with both synthetic and actual coal mine drainage samples, a conceptual treatment process for coal mine drainage is outlined and presented in the form of a flowsheet. The process involves oxidation of iron and fractional precipitation of hydrous ferric oxide with lime, followed by sludge concentration and reduction with sodium dithionite. Preliminary estimates indicate that the high reagent costs involved would make this approach less attractive than methods currently employed for coal mine drainage treatment. (From author's abstract) OR 71-23

MD71-86 REDUCTION OF HYDROUS FERRIC OXIDE TO A MAGNETIC FORM WITH SODIUM DITHIONITE: IMPLICATIONS FOR COAL MINE DRAINAGE TREATMENT

Streeter, R. C. (1), McLean, D. C. (2), and Lovell, H. L. (2) [(1) Bituminous Coal Res., Inc. and (2) The Pa. State Univ.], ACS Div. Fuel Chem. Preprints 15 (2), 13-25b (1971). This paper is based on the research reported in the first author's thesis. OR 71-32

MD71-87 STUDIES OF DENSIFICATION OF COAL MINE DRAINAGE SLUDGE

Streeter, R. C., Young, R. K., and Glenn, R. A., Bituminous Coal Research, Inc., Rept. to EPA, Office Res. Monit., Water Pollut. Contr. Res. Ser. 14010 EJT 09/71 (1971). 113 pp. NTIS, PB-203 189. The work was restricted to bench-scale batch experiments. In the first approach, lime neutralization and aeration procedures were altered to produce a dense fast-settling, ferromagnetic sludge. Disadvantages of the process were the requirement for sludge heating and its sensitivity to the presence of small amounts of aluminum in the original mine water. In the second approach, recognized conditioning methods applied to sludges included the use of coagulant aids, sludge bulk additivies (filter aids), seeding materials, and sludge heating and freezing. In addition, exploratory tests were conducted on the introduction of carbon dioxide into the mine water to promote coprecipitation of calcium carbonate during lime addition. Among the sludge densification methods tested, only magnetic sludge preparation, sludge freezing, and CO_2 pretreatment appeared to be promising. OR 71-70

MD71-88 TREATMENT OF ACID AND METAL-BEARING WASTEWATERS BY THE HIGH-DENSITY SLUDGE PROCESS

Temmel, F. M. (Homer Res. Lab., Bethlehem Steel Corp.), Am. Iron Steel Inst., Reg. Tech. Meet., San Francisco, Calif., Nov. 18, 1971. 16 pp. Bethlehem Steel Corporation developed a high density sludge process to treat acid mine waters and pickling waste waters. By recycling a controlled volume of the settled sludge and mixing the recycled sludge with lime slurry in a reaction tank prior to the neutralization and separation steps, the high density sludge is formed. The volume of the sludge is only about 1/25th the volume of that prepared by conventional neutralization. Thus, from 17 million gal/day of waste water, 43,000 gal/day instead of 990,000 gal/day of sludge is produced. OR 71-102

MD71-89 SUPPLEMENTAL IRRIGATION WITH STREAM WATER CONTAMINATED BY ACID MINE DRAINAGE

Terkeltoub, R. W. (U.S. Dept. Agr. Northeast Watershed Res. Center, University Park, Pa.), Water Resour. Res. 7 (3), 704-708 (1971). In this study, stream water carrying acid mine drainage was used in varying amounts according to a predetermined schedule to supplement the deionized water used on barley plants growing in a greenhouse. Analyses of the stream water showed a pH of 3.1, 11.2 ppm iron, 13.0 ppm manganese, 1.1 ppm zinc, 0.12 ppm copper, 0.31 ppm cobalt, and 0.42 ppm nickel. All the plants grew successfully and showed neither toxicity nor deficiency symptoms. Also the pH and extractable concentrations of iron, zinc, cobalt, and nickel of the soil were not increased. OR 71-85

MD71-90 TOBY CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT

Lee-Simpson Associates, Inc., Rept. to Pa. Dept. Environ. Resour., Proj. SL-132 (undated). 33 pp. + app. The project covered a limited portion of the watershed of Toby Creek in Elk County, Pennsylvania, which had been both deep mined and surface mined with no reclamation. The only active mine in the area at the time of the study was a surface mine where old spoil piles were being regraded and the new mining was being backfilled and planted. Water samples were taken from March 1969 through early 1970 at 12 points in the study area and at the drainage discharge of the Elk-Blue Valley Mine Complex. Results of analyses for pH, manganese, iron, alkalinity, acidity, and sulfate as well as values for flow are given. The comparison of the project area with the geographically similar abandoned mine complex indicates that with flow diversion to reduce the amount of acid generated in the deep mines, natural alkalinity from limestone formations may aid in neutralizing the acid flow. Mine sealing and water diversion are recommended as abatement measures. Specific details and cost estimates are given. OR 71-90

MD71-91 TWO LICK CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT

L. Robert Kimball, Consulting Engr., Rept. to Pa. Dept. Mines Miner. Ind., Project No. SL-109 (1971). 265 pp. This report gives the results of the survey to determine the source of water pollution in Two Lick Creek Watershed in Indiana County, Pennsylvania. Analyses of eight sub-watersheds classified as polluted include recommended abatement procedures and cost beneficiation estimates. Priorities are assigned to abatement recommendations. Four sub-watersheds have been designated not polluted. Information for each watershed includes maps of sampling stations and pollution sources; water quality data giving flow, pH, acid load, iron, and sulfate; and a graph illustrating the relationship between streamflow, pollution load, and weather. OR 71-37

MD71-92 ABATEMENT OF WATER POLLUTION

Vander Horst, J. M. A. (to United States of America), U.S. Pat. 3,694,356 (Sept. 26, 1972). 2 pp. A process for the purification of effluent from sewage treatment combined with the simultaneous purification of acidic mine drainage by combining the two streams in suitable proportions so as to precipitate water insoluble iron phosphates. (Abstract of the disclosure) OR 71-110

MD71-93 DISTRIBUTION OF BIOTA IN A STREAM POLLUTED BY ACID MINE-DRAINAGE

Warner, R. W. (Div. of Field Invest., EPA, Denver), Ohio J. Sci. 71 (4), 202-215 (1971). Acidic water draining from coal mines has severely restricted the diversity of biota inhabiting Roaring Creek, eastern West Virginia. Polluted reaches of the stream (medium pH values ranging from 2.8 to 3.8) were inhabited by 3 to 12 genera of bottom-dwelling invertebrates and 10 to 19 species of periphytic algae. Sections of Roaring Creek not severely polluted by acid drainage (pH medians of 4.5 or higher) supported diverse communities of 25 or more kinds of benthic animals and 27 or more species of periphytic algae. Because of the complex and varying chemical composition of the acid mine drainage, and also because of possible physical influences, measurements of pH values in the stream seemed to provide the most reliable, as well as unique, index of the effects of acid mine-drainage on aquatic life. (Author's abstract adapted) OR 71-82

MD71-94 WEST VIRGINIA WATER QUALITY NETWORK - 1967

W. Va. Dept. Natural Resour., Div. Water Resour., 1971. 85 pp. This report lists the water quality regulations for West Virginia including acid mine drainage control measures. A discussion is included on the West Virginia Water Pollution Control Act and its authoritative powers. Results of chemical and biological analyses and properties such as temperature, turbidity, and odor number from sampling stations on the major rivers and streams in West Virginia in 1967 are tabulated. OR 71-103

MD71-95 WEST VIRGINIA WATER QUALITY NETWORK - 1968

W. Va. Dept. Natural Resour., Div. Water Resour., 1971. 149 pp. This report contains the water quality regulation for the state of West Virginia including acid mine drainage control measures. The report also contains water analyses data for samples taken at the many sampling stations in the state. OR 71-104

MD71-96 MICROBIOLOGICAL TREATMENT OF ACID MINE DRAINAGE WATERS

Whitesell, L. B., Jr., Huddleston, R. L., and Allred, R. C., Continental Oil Co., Rept. to EPA, Office Res. and Monitoring, Water Pollut. Contr. Res. Ser. 14010 ENW 09/71 (1971). 78 pp. NTIS, PB-206 231. In laboratory studies, both pure cultures and fresh field cultures of acidophilic iron bacteria readily oxidized ferrous iron in synthetic and natural acid mine waters at rates up to 600 mg/1/hr. Approximate requirements of oxygen, carbon dioxide, nitrogen and phosphorus by the iron bacteria were established. Multistaging of oxidation vessels in series produced a more effective microbial oxidation system than a single reservoir. Limestone

MD71-96 (continued)

neutralizations of partially oxidized acid mine waters showed that such waters containing up to 90 mg/l ferrous iron could be successfully neutralized and result in discharge waters containing less than 7 mg/l total iron. Attempts to duplicate laboratory findings with a 2,000-gallon pilot plant were not completely successful. Although sulfate-reducing bacteria were isolated from all of nine acid mine discharges examined, attempts to grow the cultures or produce hydrogen sulfide at pH values below 5.5 were unsuccessful. (From authors' abstract) OR 71-76

MD71-97 THE MICROBIOLOGICAL OXIDATION OF FERROUS IRON IN MINE DRAINAGE WATER--PILOT PLANT STUDIES

Whitesell, L. B., Jr. (1), Huddleston, R. L. (1), and Kosowski, Z. V. (2) [(1) Continental Oil Co. and (2) Consolidation Coal Co.], Presented, ACS 162nd Natl. Meet., Washington, D. C., Sept. 12-17, 1971. 13 pp. There were significantly lower oxidation rates of ferrous iron in the pilot plant treatment system than were predicted by previous bench-scale work. Therefore, the approximately 500 ppm ferrous iron mine water feed used in the pilot plant was treated in the bench-scale apparatus. With the same bacteria count used in the pilot plant, a more rapid rate of ferrous oxidation was observed in the bench-scale unit. It is suggested that the different surface to volume ratio between pilot and bench-scale systems should be investigated as a possible cause of the difference in oxidation rates. The methods and results are reported in detail. OR 71-57

MD71-98 DISPOSAL OF SLUDGE FROM ACID MINE WATER NEUTRALIZATION

Yeh, S.-J. and Jenkins, C. R. (Dept. Civil Eng., W. Va. Univ.), J. Water Pollut. Contr. Fed. 43, 679-688 (1971). The sludge used in the dewatering studies was taken from the Christopher Coal Co. acid mine drainage treatment plant located south of Mount Morris, Pa. The design of a thickener, a vacuum filter, and a sand drying bed were determined in the laboratory. Thickening followed by sand-bed drying may offer a reasonable process. Vacuum filtration was unsuccessful. In greenhouse experiments, the addition of neutralization sludge and/or domestic wastewater sludge to mine spoil raised the pH to the 7.0 to 8.0 range, and mixtures of the sludges promoted growth. OR 71-92

1972

MD72-1 AN ANALYSIS OF THE ZOOPLANKTON COMMUNITY IN AN ACID POLLUTED RESERVOIR

Bible, J. L., Proc. W. Va. Acad. Sci. 44 (1), 32-39 (1972). This study was made to examine the zooplankton community in the acid polluted Cheat Lake, West Virginia and two of its backwaters. Results indicate the zooplankton population in the backwaters was much higher than it was in the high acid lake. Data information are tabulated for each sampling station. Further study is needed to understand the ability of acid water to maintain zooplankton populations of particular abundance and composition. OR 72-101

MD72-2 STATUS OF COAL MINE DRAINAGE CONTROL TECHNOLOGY

Boyer, J. F., Jr. (Bitum. Coal Res., Inc.), Coal Mining & Process. 9 (1), 56-59 (1972). In reviewing the scope of the mine drainage problem, the author emphasizes the fact that the major part of the problem is drainage from abandoned mines. The role of industry and of state and federal governments is discussed in relation to control measures which either can be permanent and prevent further formation or discharge of mine drainage, or can be temporary, such as neutralization, and only effect an improvement while they are being carried on. OR 72-47

MD72-3 COAL AND COAL MINE DRAINAGE

Boyer, J. F. and Gleason, V. E. (Bitum. Coal Res., Inc.), J. Water Pollut. Contr. Fed. 44 (6), 1088-1093 (1972). There are 52 references in this review of the literature of 1971. Included are basic studies on the formation of acid mine drainage, studies of new abatement methods, watershed studies, and reports of neutralization and sludge handling. OR 72-46

MD72-4 TREATMENT OF MINE DRAINAGE

Burke, L. O. and Cudmore, J. F., Australian Coal Industry Res. Lab. Ltd., P.R. 72-75, June 1972. 25 pp.+ A survey has been made of different drainage types produced from a number of operating collieries in both New South Wales and Queensland. A laboratory study has been made of treatment of acid mine drainage using the principle of autogenous grinding of lump limestone in a tube mill. A number of techniques have been described for evaluating the chemical, microscopic and grindability characteristics of limestones. The design and operation of a pilot tube-mill has been described and its method of operation, using an actual sample of acid mine drainage, is illustrated. (From authors' Summary) OR 72-75

MD72-5 TRACE ELEMENT DISTRIBUTION IN REACTIVE AND INERT PYRITE

Caruccio, F. T. (Univ. South Carolina), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 48-54. This is a report of a continuing study of the nature and distribution of pyrite which oxidizes to form the acid drainage associated with coal mining. Previously, two forms of pyrite were identified, a stable form and a highly reactive "framboidal" or fine grained form. Particle size alone was not a factor in the difference in reactivity since stable pyrite did not become reactive when it was finely ground. In further studies to identify differences between the two forms a minute amount of sample was vaporized by laser beam and the vapor analyzed by spectrometer. The presence of silver in reactive pyrite and of more titanium in stable than in reactive pyrite are the only consistent differences found in the analyses of 18 samples. No conclusions are drawn as the study is continuing. OR 72-7

MD72-6 POLLUTION CONTROL UNDER THE PENNSYLVANIA CLEAN STREAMS LAW

Charlson, A., Univ. Pittsburgh Law Rev. 34 (115), 115-129 (1972). The definition of pollution under the Clean Streams Law is discussed. Pollution incidents at a number of coal companies are used as examples. An attribute of Pennsylvania's system of pollution control is that violation or compliance can be determined at the discharge point alone. OR 72-88

MD72-7 CLARION RIVER ACID MINE DRAINAGE ABATEMENT PROGRAM, PENNSYLVANIA

U.S. Dept. Army, Washington, D.C., Draft Environ. Impact Statement, May 1972. 15 pp. NTIS, EIS-PA-72-4585-D. A program using several different mine drainage pollution abatement techniques to improve the Clarion River is described and the probable effects are discussed. OR 72-71

MD72-8 AQUATIC VASCULAR PLANT DISTRIBUTION IN CHEAT LAKE (LAKE LYNN), WEST VIRGINIA

Clovis, J. F. (W. Va. Univ.), Castanea 36, 153-163 (1971). A compiling of the aquatic vascular plants of Cheat Lake, with notes as to their abundance and distribution, is given. Cheat Lake is fed by Cheat River, which is becoming increasingly mine-acid polluted, and a record of the plants and some present conditions was considered important to future studies. Ten new county records and two new state records are included. (Author's abstract) OR 72-54

MD72-9 A PRELIMINARY DESCRIPTION OF THE PHYSICO-CHEMICAL CHARACTERISTICS AND BIOTA OF THREE STRIP MINE LAKES, SPENCER COUNTY, INDIANA

Coe, M. W. and Schmelz, D. V. (St. Meinrad College), Proc. Ind. Acad. Sci. 82, 184-188 (1972). Three Spencer County surface mine lakes in the same immediate area, each about 30 years old were studied. Differences between the characteristics of the lakes are a function of the area/volume ratios, slopes of basins, and watersheds. These lakes are in the alkaline stage of recovery. The study results prove that each lake is modified, chemically, physically, and biotically at its own rate. OR 72-103

MD72-10 COOPERATIVE MINE DRAINAGE SURVEY - KISKIMINETAS RIVER BASIN

EPA, Wheeling Field Office (April 1972). 313 pp.+ app. Basic data on sources of coal mine drainage in seven watersheds of the Kiskiminetas River basin: the Kiskiminetas River - mainstem and tributaries; Loyalhanna Creek; Conemaugh River - mainstem and minor tributaries; Blacklick Creek; Two Lick Creek; Little Conemaugh River; and Stony Creek include an inventory of mine discharges; stream water samples analyzed for pH, acidity, alkalinity, hardness, sulfate, total iron, and manganese; and flow. The mine drainage discharges were analyzed for pH, specific conductance, acidity, hardness, sulfate, total iron, manganese, and aluminum. A 1966 survey of water quality in the basin is reviewed. Recommendations for a program to reduce mine drainage pollution in the area are presented. OR 72-39

MD72-11 CHEMICAL CHANGES IN STREAMFLOW FOLLOWING SURFACE MINING IN EASTERN KENTUCKY

Curtis, W. R. (Forest Service, U.S. Dept. Agriculture, Ky.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 19-31. This is a part of a continuing study to evaluate effects of surface mining on small Appalachian watersheds. Since acid pollution is not a problem, other chemical effects of surface mining can be followed. An undisturbed area was used for comparison with the mined areas. Water quality data collected before and after mining in 5 mined watersheds include values for specific conductivity, pH, iron, aluminum, manganese, sulfate, calcium, magnesium, zinc, copper, and alkalinity. All of the minerals except copper showed an increase after mining activity. Aluminum and manganese concentrations seem to peak and taper off quickly. Sulfate, calcium, and magnesium show the greatest increase after mining although the increase in sulfate concentration appears several months after other increases. Specific conductivity which indicates overall concentration of mineral salts is suggested as a single test to indicate degree of water pollution. OR 72-3

MD72-12 DEWATERING SLUDGE BY USING ROTARY VACUUM PRECOATING FILTRATION

Davis, D. W., Brown, T. S., and Long, B. W. (Johns-Manville Products Corporation),

MD72-12 (continued)

Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 201-233. In this process, a drum that has been thickly coated with a filter aid is rotated through sludge to be filtered. In the continuous operation, liquid is drawn into the vacuum system and solids are deposited on the drum. As the drum rotates out of the sludge, air drawn through the deposit and the precoat further dewaters the sludge, which is scraped off by an advancing knife edge so that a clean surface is exposed for filtration. Pilot studies were carried out on actual mine water sludges at 9 sites in West Virginia and at 5 sites in Pennsylvania. Results obtained from using various filter aids and alkali systems show CELITE 501 to be the best filter aid and limestone-lime combination the best neutralization system. Cost estimates are given for various treatment plants. OR 72-16

MD72-13 METHOD OF SUBSIDENCE AND ACID ENTRAINED DRAINAGE CONTROL AND ADMIXTURES THEREFOR

Davis, W. A. (to Michael L. Vongrey, Jr., Kittanning, Pa.), U.S. Pat. 3,704,594 (Dec. 5, 1972). 9 pp. The purpose of this method is to fill underground mine voids and to neutralize and control acid drainage coming from such voids. OR 72-70

MD72-14 FINANCING ABATEMENT OF MINE DRAINAGE POLLUTION: CASE STUDY APPALACHIA

Dee, N., Stacey, G., Bowman, J., and Qasim, S. (Battelle Memorial Inst.), Water Resour. Bull. 8 (3), 473-482 (1972). A financing program for the prevention, control, and abatement of mine drainage pollution was developed using Appalachia as a case example. The financing program was selected by using three performance criteria in a screening process--applicability of financing program to pollution problem, feasibility of program to unit costs and capturing potential benefits, and feasibility of program to economic and legal consideration. Effluent charges with some modifications are suggested as the appropriate financing mechanism. (Authors' abstract) OR 72-63

MD72-15 A COMPARATIVE STUDY OF PLANKTON RESPIRATION IN AN ACID POLLUTED LAKE AND ITS ACID FREE EMBAYMENTS

Diehl, W. T. (W. Va. Univ., Dept. Biol.), Proc. W. Va. Acad. Sci. 44 (1), 24-32 (1972). A 30-day study of community respiration in Cheat Lake, West Virginia, compared communities in the acid lake and in two acid free backwaters. Data indicated a marked decrease both in surviving species and in species concentration in the lake. It was suggested that the significant difference in community respiration between the non-acid backwaters might be due to a difference in available nutrients. OR 72-100

MD72-16 AQUATIC-BIOTIC COMMUNITY STRUCTURE AS AN INDICATOR OF POLLUTION

Dills, G. G. and Rogers, D. T., Jr., Geol. Surv. of Ala., Div. of Water Resour., University, Ala., Circ. 80, (1972). 25 pp. Bi-weekly sampling was carried out at ten stations in the drainage basin of Cane Creek, Walker County, Alabama, from February 1970 through January 1971. Water samples were analyzed in the field for dissolved oxygen, conductivity, temperature, pH, iron and manganese. Laboratory analyses were carried out for turbidity, phosphate, nitrate, silica, alkalinity, hardness, chromium, and chloride. Benthic samples were collected from riffles in the same general area as the water samples. Mine drainage resulted in low community diversity. OR 72-86

MD72-17 MINE DRAINAGE TREATMENT EXPERIENCE

Draper, J. C. (Duquesne Light Co.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 415-422. A treatment plant to be run parallel to the presently operating treatment plant at the Warwick No. 2 Mine is described. The new plant is designed for a flow of 6 million gallons per day of mine water with

MD72-17 (continued)

1950 ppm acidity and 900 ppm iron. In the treatment process, mine water is neutralized by lime, aerated, and sent to a sludge thickener. The overflow from the thickener can go either to a polishing pond or to the receiving stream. The sludge is disposed of in an abandoned mine. Modifications, based on experience with the first plant, have been made in the new plant in the lime slurry feed system and in the receptacle which serves as a sludge thickener. OR 72-29

MD72-18 THE EFFECTS OF STRIP MINING UPON NAVIGABLE WATERS AND THEIR TRIBUTARIES: DISCUSSION AND SELECTED BIBLIOGRAPHY

Grad. Center for Public Works Admin., Univ. Pittsburgh for Corps of Engineers, U.S. Dept. of the Army, July 1972. 94 pp. NTIS, AD-749 802. The emphasis of this review of the literature is on the sedimentation and acid mine drainage attributable to surface mining for coal. The effects of other types of surface mining are briefly reviewed. OR 72-55

MD72-19 ENVIRONMENTAL PROTECTION--A CONSOL OBJECTIVE SINCE 1948

Coal Age 77 (10), 122-138 (1972). The overall mine drainage, reclamation and waste disposal program of Consolidation Coal Company is described. Fifteen water treatment plants are in operation and three more in development stages. Major projects for the company include: Itmann preparation plant, Hanna Coal Company Division reclamation program, the Pocahontas Fuel Company reclamation project, and Dents Run surface and water cleanup. OR 72-79

MD72-20 AIRBORNE INFRARED DETECTION AND MAPPING OF COAL MINE DRAINAGE

Fisher, W., Jr. (HRB-Singer, Inc.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 331-339. Seasonal experiments over a subwatershed illustrate the utility of this approach in establishing the relative quantity of acid mine water with seasonal hydrologic change. Successful application of the IR technique is dependent on the optimum usage of the airborne operational parameters of time of overflight, flight direction, altitude, and the spatial and thermal characteristics of the system. Seasonal influences on ambient temperature, water flow and vegetation also have to be considered in order to optimize the thermal contrast of the water sources and drainage relative to their background. (From author's abstract) OR 72-23

MD72-21 DEVELOPMENT OF A LIMESTONE TREATMENT PROCESS FOR ACID MINE DRAINAGE

Ford, C. T. (Bituminous Coal Research, Inc.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 266-291. Laboratory studies on both actual and synthetic mine waters with high ferrous iron content show that limestone treatment is feasible. The process described in this paper includes recirculation of a slurry of mine drainage sludge and treated effluent with coal mine drainage feed. A flow diagram and unit design basis are presented for a plant treating 4.0 mgd of water characterized by pH above 4 and ferrous iron concentration of about 100 mg/l. Studies are underway to improve the process by increasing the rate of iron oxidation. Cost estimates show that the BCR limestone treatment process compares favorably with other neutralization processes. OR 72-19

MD72-22 EVALUATION OF MINE SEALING IN BUTLER COUNTY, PENNSYLVANIA

Foreman, J. W. (Gwin, Dobson & Foreman, Inc.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 83-95. Brief descriptions of various methods of mine sealing are included in this report on two mine sealing projects to control pollution in western Pennsylvania. In one project 69 hydraulic and 23 dry or surface seals were installed on openings draining into Muddy Creek, the source of water for Lake Arthur in Moraine State Park. Eighty-five weirs, installed at known mine drainage discharges, were used as sampling and flow monitoring points. Water quality

MD72-22 (continued)

was also monitored through mine observation holes. The other project was carried out in the eastern end of Slippery Rock Creek Watershed and included 32 hydraulic mine seals and several hundred feet of grout curtain at two locations along the coal outcrop. Water samples and flow measurements were obtained at seven locations and further sampling was done through six mine observation holes in this second project. Water quality analyses and flow measurements made before and after sealing in both projects show a decrease in mine water discharge and an improvement in water quality. Costs are summarized. OR 72-10

MD72-23 ELECTROCHEMICAL OXIDATION OF ACID MINE WATERS

Gaines, L., Jasinski, R., and Gruber, A. (Tyco Laboratories, Inc.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 105-114. The electrochemical oxidation of ferrous iron process is proposed as a substitute for the commonly used aeration step. Laboratory studies on synthetic mine water at constant flow rates, which were varied from 2 to 20 gallons per hour, show that this process is technically feasible. The reactor design uses a packed bed of activated granular carbon as an anode since theoretical consideration of mass transport limitation of oxidation shows that an economical reactor must be based on a relatively large surface area of anode per unit volume. OR 72-12

MD72-24 CONTROL OF POLLUTION FROM DEEP BITUMINOUS COAL MINES IN PENNSYLVANIA

Giovannitti, E. F. (Pa. Dept. Environ. Resour., Div. Mine Drainage & Erosion Control), AIME Ann. Meet., San Francisco, Calif., 1972. 72-F-85. 17 pp. The prevention and abatement of acid mine drainage pollution is reviewed with emphasis on sealing of abandoned mines and neutralization of acid waters. OR 72-73

MD72-25 LEGAL PROBLEMS OF COAL MINE RECLAMATION

Goldberg, E. F. and Power, G., Univ. Md., School of Law, Rept. to EPA, Water Pollut. Contr. Res. Ser. 14010 FZU 03/72 (1972). 236 pp. NTIS, PB-290 862. Coal mining produces a variety of environmental problems -- acid drainage, sedimentation, surface subsidence and surface scars. This study reviews the response of legal institutions to these problems in Maryland, Ohio, Pennsylvania, and West Virginia. Technological and economic concerns are also taken into account. The study examines the way in which the property system allocates rights in coal and coal lands, the efficacy of litigation, and present laws and regulations for preventing environmental damage, and constitutional limitations on the ability of states to effectively respond to the problems. A case study of the economics of the Maryland coal industry is also presented. Model legislation giving the states the necessary powers to respond to environmental problems, is proposed. (From authors' abstract). There are 345 references. OR 72-36

MD72-26 EFFECTS OF COAL MINING ON THE WATER RESOURCES OF THE TRADEWATER RIVER BASIN, KENTUCKY

Grubb, H. F. and Ryder, P. D., U.S. Geol. Survey, Water-Supply Paper 1940, (1972). 83 pp. The effects of coal-mine drainage on the water resources of the Tradewater River basin, in the Western Coal Field region of Kentucky, were evaluated (1) by synthesis and interpretation of 16 years of daily conductance data, 465 chemical analyses covering an 18-year period, 28 years of daily discharge data, and 14 years of daily suspended-sediment data from the Tradewater River at Olney and (2) by collection, synthesis, and interpretation of chemical and physical water-quality data and water-quantity data collected over a 2-year period from mined and nonmined sites in the basin. (From authors' abstract) OR 72-85

MD72-27 SIGNIFICANCE OF WEATHERING IN A PENNSYLVANIAN SANDSTONE TO POLLUTION FROM STRIP MINES

Grube, W. E., Jr., Smith, R. M., Jencks, E. M., and Singh, R. N. (W. Va. Univ.), Nature 70-71 (March 10, 1972). Sandstone that overlays upper Freeport coal in northern West Virginia has been analyzed at various depths. Weathering has penetrated sandstone generally about 6 meters, and to a greater depth along rock fractures. Pyrite and soil nutrients are mainly absent in the weathered layer. Lower strata have sulfur content varying from several tenths of a percent near the coal seam to less than one tenth of a percent near the top of the unweathered zone. OR 72-34

MD72-28 MINE DRAINAGE DEMONSTRATION PROJECTS

Hall, E. P. (Environmental Protection Agency), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 32. The major EPA demonstration projects are summarized. OR 72-4

MD72-29 FOAM SEPARATION OF METALS FROM ACID MINE DRAINAGE

Hanson, P. J. (Horizons Research Incorporated), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 157-178. Laboratory scale apparatus was used to determine the technical and economic effectiveness of continuous-flow foam separation for treating acid mine drainage. Results of the work carried out on synthetic acid mine drainage were verified by tests run on mine drainage from Grassy Run near Elkins, West Virginia. The process is not economically feasible since only a low percentage of the metals present in the mine water is extracted. OR 72-14

MD72-30 THE RECOVERY OF STREAM MACROBENTHIC COMMUNITIES FROM THE EFFECTS OF ACID MINE DRAINAGE

Herricks, E. E. and Cairns, J., Jr. (Va. Polytechnic Inst. and State Univ.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 370-398. A study was carried out on Indian Creek, a tributary of the Youghiogheny River in Pennsylvania, to determine the ability of a stream to recover from effects of acid mine drainage pollution. Stations for sampling water quality and the types and density of biological population were located both upstream and downstream of the drainage source and within the polluted area. Sampling was carried out from October 1970 through October 1971. Among the conclusions from the results of the sampling program are: that the effects of acid drainage on aquatic communities includes a reduction in diversity and density of organisms and a dominance by pollution-tolerant organisms; and that recovery was shown by establishment of communities with a large number of species most of which were represented by relatively few individuals. OR 72-27

MD72-31 CONTROL AND PREVENTION OF MINE DRAINAGE

Hill, R. D. (Chief, Mine Drainage Pollut. Contr. Act., Cincinnati, Ohio), Battelle Conf., Columbus, Ohio, Nov. 1972. 12 pp. Also in Cycling and Control of Metals, Proceed. Environ. Resour. Conf. Oct. 31-Nov. 2, 1972 (1973). pp 91-94. NTIS, PB-216 184. Acid mine drainage formation and abatement of mine drainage pollution are reviewed. OR 72-66

MD72-32 ELKINS MINE DRAINAGE POLLUTION CONTROL DEMONSTRATION PROJECT--AN UPDATE

Hill, R. D. and Martin, J. F. (EPA, Cincinnati, Ohio), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 96-104. Information gained on the Elkins, West Virginia mine drainage control project includes data showing long term improvements in water quality, and establishment of grasses, legumes, and trees in various areas. Each of the several subwatersheds into which the project is divided is described. Mine sealing did not reduce oxygen concentration in the mines nor decrease pollution load, but did reduce acidity and sulfate somewhat. Surface

MD72-32 (continued)

reclamation has been successful in decreasing pollution from surface drainage. Greater precipitation over the area, resulting in larger flows in some years has contributed to larger loadings of pollutants expressed as tons per year. Continuous monitoring of water quality rather than intermittent sampling is recommended to give better information on water quality changes. OR 72-11

MD72-33 ACID MINE DRAINAGE TREATMENT BY ION EXCHANGE

Holmes, J. G. and Kreusch, E. G., Culligan International Company, Rept. to EPA, Environ. Protection Technol. Ser. EPA-R2-72-056 (Nov. 1972). 215 pp. NTIS, PB-214 454. Laboratory studies were conducted on synthetic acid mine drainage treatment using ion exchange processes. During the first stage, five representative ion exchange resins were surveyed through laboratory column test studies. In the second stage of the laboratory studies the three resins which were feasible in the treatment of AMD in the first stages were selected and studied further in the treatment of synthetic AMD containing 100% ferrous iron and containing 100% ferric iron. Based on the laboratory studies, two complete processes for the treatment of AMD by ion exchange techniques were established: a two resin system and the modified Desal system. Treatment plants were designed for each system and cost estimates are presented in the report. (From authors' abstract) OR 72-61

MD72-34 ION EXCHANGE TREATMENT OF ACID MINE DRAINAGE

Holmes, J. and Schmidt, K. (Culligan International Company), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 179-200. Five ion exchange methods were evaluated for treating acid mine drainage. Three methods were considered to be of value for further study. Two of these methods, strong acid cation exchange in the hydrogen cycle and weak base anion exchange in free base cycle, are combined into a two-step treatment which is a conventional ion exchange process. Although the manganese in the effluent was considerably less than its concentration in the synthetic mine water, there was more than the limit of 0.05 ppm manganese required in potable water. It was necessary to increase the pH of the effluent to 9.90 with lime to remove sufficient manganese to meet this standard. The third ion exchange method, a weak base anion exchanger in bicarbonate cycle, was combined with lime treatment of its effluent for a second mine drainage treatment process. Both mine drainage treatment processes were carried out on synthetic mine water with iron all in the ferric state and with iron all in the ferrous state. OR 72-15

MD72-35 THE EFFECTS OF ACID MINE WATER ON GROWTH (NUMBER AND SIZE) OF CHLORELLA VULGARIS

Janeczek, W. A., Keller, E. C., III, Shoupp, W. J., and Keller, E. C., Jr., Proc. W. Va. Acad. Sci. 44 (1), 40-49 (1972). Growth in Chlorella vulgaris was examined under axenic conditions in a variety of Acid Mine Water (AMW) concentrations, and inorganic nutrient media, to ascertain the relationship between cell number and cell size. It was found that high concentrations of AMW (above 3/16) decreased the average cell size. Further, at concentrations of 3/16 AMW or more, cell number was greatly decreased. Finally, the normal relationship that exists between cell size and cell number during growth was greatly modified by AMW concentrations greater than 3/16. (Authors' abstract) OR 72-102

MD72-36 ELECTROCHEMICAL TREATMENT OF ACID MINE WATERS

Jasinski, R. and Gaines, L., Tyco Laboratories, Inc., Rept. to EPA, Water Pollut. Contr. Res. Ser. 14010 FNQ 02/72 (1972). 81 pp. NTIS, PB-208 820. Experimental and analytical evaluations of the direct electrochemical oxidation of ferrous acid mine drainage have shown that this approach is economically superior to present lime treatment and aeration methods. Through the use of a packed bed electrode, the size of the oxidation reactor has been reduced to a stage where the capital investment required for this equipment can be recovered by cost reductions in latter treatment stages. Electrolytic hydrogen, produced during electrochemical oxidation, should be economically recoverable at high AMD treatment rates. (From authors' abstract) OR 72-32

MD72-37 PROGRESS IN THE RECOGNITION OF FRACTURED ROCK ZONES IN PREVENTION AND ABATEMENT OF MINE DRAINAGE

Koppe, E. F. (1) and Thompson, D. R. (2) [(1) E. F. Koppe & Associates and (2) Pa. Dept. Environ. Resour.], Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 41-47. Fracture traces, or fractured rock zones, breaks in the earth's surface varying from feet to miles in length, can alter ground water flow and can result in mine roof problems or failure of mine seals. Aerial photography aids in their identification. Examples are given of the application of this knowledge to reducing the amount of water that must be handled during mining and that might also need mine drainage treatment. OR 72-6

MD72-38 CONTROL OF MINE DRAINAGE FROM COAL MINE MINERAL WASTES

Kosowski, Z. V. (Consolidation Coal Co.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 423-424. Continuing work on the reclamation of the refuse piles and slurry lagoons at the New Kathleen Mine, DuQuoin, Illinois is described. The pile has been graded, covered with clean earth, fertilized, and planted. Three test plots of approximately 10 acres each were covered with 1, 2, and 3 foot thicknesses of earth. Half of the slurry lagoon area was treated with a petroleum based non-toxic emulsion for dust abatement. The rest of the lagoon area was fertilized and planted with grasses but without topsoil. Water quality monitoring is presently going on. OR 72-30

MD72-39 MINING AND RECLAMATION TECHNIQUES TO CONTROL MINE DRAINAGE

Krause, R. R. (National Coal Association), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 425-430. Newer methods of mining and reclamation which are reviewed are designed to minimize the problems associated with mining in the steep areas of Appalachia. The basic purposes of the various methods are to create a stable earth mass from the overburden that must be moved and to prevent erosion, siltation, and landslides by controlling water runoff from rainfall and by rapidly establishing a vegetative cover. OR 72-31

MD72-40 MINE DRAINAGE AND OTHER MINING IMPACTS AS A REGIONAL DEVELOPMENT CONCERN

Lerch, O. H., Maneval, D. R., and Montgomery, H. B. (Appalachian Regional Comm.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 15-18. The purpose and work of the Appalachian Regional Commission are described. Special emphasis is given to the effect of mine drainage in the region and the Commission's role in alleviating the problem, particularly in relation to the Monongahela River Basin Project. OR 72-2

MD72-41 TECHNICAL AND ECONOMIC EXPERIENCE IN THE OPERATION OF THE SLIPPERY ROCK CREEK MINE WATER TREATMENT PLANT

Lisanti, A. F. (1), Zabban, W. (1), and Maneval, D. R. (2) [(1) The Chester Engineers and (2) Appalachian Regional Comm.], Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 399-414. While the plant is designed to treat a flow of approximately 2100 gpm, the actual influent from the stream has averaged 2520 gpm. The lime slurry treatment of the creek water increased the pH from about 4 to more than 7 and completely removed the iron which was present at a concentration of between 2 and 3 mg/l. The neutralized water is sent to a clarifier. The settled solids go to a thickener and then to sludge storage lagoons where the sludge compacted to about 7 percent total solids. Operators are present at the treatment

MD72-41 (continued)

facility during two shifts. The plant operates automatically during the third shift with an alarm system tied into telephone lines to summon help if needed. OR 72-28

MD72-42 EXPERIENCE WITH BIOCHEMICAL-IRON-OXIDATION LIMESTONE-NEUTRALIZATION PROCESS

Lovell, H. L. (Mine Drainage Res. Sect., Penn. State Univ.), Fourth Symp. Coal Mine Drainage Res., Pittsburgh, Pa., by Coal Ind. Advisory Comm. to ORSANCO (1972). 10 pp. The long term experience of treating acid mine drainage by the two step process of bacterial oxidation of ferrous iron and limestone neutralization is discussed. The influent mine water has a pH of about 3.0 and ferrous iron content of about 430 mg/l. The treatment effluent has a pH of 6.5 and total iron content of 1 mg/l. Biochemical oxidation of ferrous iron in two different types of reactors was compared. Oxidation in a surface reactor, similar in design to a conventional sewage trickling filter occurred apparently several hundred times faster than oxidation in a deep vat system in which the mine water and culture were mechanically agitated. OR 72-20

MD72-43 OPERATING EXPERIENCE WITH BIOLOGICAL IRON OXIDATION - LIMESTONE NEUTRALIZATION TREATMENT OF COAL MINE DRAINAGE

Lovell, H. L. and Kaelin, D. E. (Mine Drainage Res. Section, Pa. State Univ.), AIME Ann. Meet., San Francisco, Calif., 1972. 72-F-104. 7 pp.+ Treatment experience with water containing up to 500 mg/l ferrous iron is reported. OR 72-74

MD72-44 MULTISTAGE FLASH EVAPORATION SYSTEM FOR THE PURIFICATION OF ACID MINE DRAINAGE

Maneval, D. R. (1) and Lemezis, S. (2) [(1) Appalachian Regional Commission and (2) Westinghouse Elec. Corp.], Trans. of the Soc. of Mining Engineers of AIME 252, 42-45 (1972). The system to treat drainage near Wilkes-Barre is described. OR 72-41

MD72-45 PHYSIOLOGY OF ACIDOPHILIC BACTERIA OF ACID MINE WATER

Manning, H. L. and Cook, T. M. (Dept. Microbiology), Univ. Maryland, Completion Rept. A-016-Md to U.S. Dept. Int., Office Water Resour. Res., Feb. 1972. 50 pp. Two new acidophilic bacteria (strains M-1 and M-2) were isolated from acid mine water and characterized. The range of pH over which they grow well is pH 2.5 to 4.5, and above pH 4.5 definite morphological abnormalities (swelling and rounding of cells) occur. Their response to various metals and to organic and inorganic sources of nitrogen has been determined. (Adapted from authors' abstract) OR 72-60

MD72-46 TWOFOLD ATTACK ON THE DRAINAGE PROBLEM

Mason, R. H., Coal Mining & Process. 9 (10), 44-48 (1972). The Whetstone Portal Treatment Plant which treats water from Consol No. 20 Mine, of the Mountaineer Coal Co. is described. The mine drainage is neutralized by hydrated lime and the effluent "of above state standards" goes into Whetstone Run, a tributary of Buffalo Creek in the Monongahela watershed. OR 72-67

MD72-47 REVERSE OSMOSIS DEMINERALIZATION OF ACID MINE DRAINAGE

Mason, D. G. and Gupta, M. K. (Rex Chainbelt Inc.), Rept. to EPA, Office Res. Monit., and Pa. Dept. of Environ. Resour., Water Pollut. Contr. Res. Ser. 14010 FQR 03/72 (1972). 110 pp. NTIS, PB-211 020. The study was conducted in two phases. Phase I consisted of laboratory bench scale investigations to determine methods for controlling iron fouling and to select a process flow sheet. Phase II was the field operation located in Mocanaqua, Pennsylvania, using the discharge from an abandoned underground anthracite coal mine. Treatment prior to RO consisted of filtration

MD72-47 (continued)

(10μ) followed by ultraviolet light disinfection. The brine from the RO unit was treated by neutralization, oxidation and settling. The results of a four-month test indicated that it was feasible to demineralize acid mine drainage by reverse osmosis. Membrane fouling due to iron was satisfactorily controlled. The recovery of product water was limited to about 75% due to calcium sulfate fouling. Product water was of potable quality in all respects except for iron, manganese, and pH. (From authors' abstract) OR 72-37

MD72-48 COPPER, NICKEL, AND ZINC RELEASED FROM ACID COAL MINE SPOIL MATERIALS OF EASTERN KENTUCKY

Massey, H. F. and Barnhisel, R. I. (Univ. of Ky.), Soil Science 113 (3), 207-212 (1972). Successive extractions and leachings of seven coal mine spoils were carried out over a period of 35 weeks. Concentrations of Fe, Al, Mn, Ca, Mg, and Na found in the extractions were generally similar to those reported by other workers but as much as 122 ppm Ni, 85 ppm Cu, and 145 ppm Zn occurred in the soil solutions analyzed in this study. Concentrations of Fe, Al, Mn, Zn, Cu, and Ni were generally higher in extracts of low pH. It is suggested that possible toxicities from Ni, Cu, and Zn must be considered in revegetating spoil banks. OR 72-40

MD72-49 THE USE OF RESISTIVITY TECHNIQUES TO DELINEATE ACID MINE DRAINAGE IN GROUND WATER

Merkel, R. H. (Penn. State Univ.), Ground Water 10 (5), 38-42 (1972). This paper describes a ground water resistivity project conducted in the Kylertown area of Pennsylvania, to measure the extent of contamination by acid mine water. Chemical analyses of streams and ground water samples were made to monitor the degree of contamination. Data are shown on several charts which plot resistivity against ion concentration. Variable resistivity of the coal associated with the acid water had some undetermined affect on the water. OR 72-92

MD72-50 THE USE OF IONIC TRACERS IN DETERMINING THE SUBSURFACE FLOW OF MINE DRAINAGE. A CASE STUDY.

Merritt, G. L. (1) and Angerman, T. W. (2) [(1) Pa. Dept. Environ. Res. and (2) Huntley & Huntley, Inc.], Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 340-343. Advantages and disadvantages of various kinds of tracers are discussed. Ionic tracers, manufactured chemical compounds, can be most reliable but also must be added with care not to cause harmful effects to the hydrological environment. In the case study of three public water supply wells in the Clarion River area a hydrogeological investigation provided the guidelines for the use of tracers. The results of the study showed that the test well was in communication with both deep and surface mines. OR 72-24

MD72-51 U.S. BUREAU OF MINES PROGRESS IN MINE WATER RESEARCH

Mihok, E. A. and Moebs, N. N. (U.S. Dept. Int., Bur. Mines, Pgh.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 33-40. Past and current work reviewed includes continuing studies on effectiveness of mine sealing, development of a limestone neutralization process, and collection and evaluation of field data as the basis of developing technology for mine drainage control. OR 72-5

MD72-52 MINING GUIDEBOOK - MINE DRAINAGE AND ACID WATER TREATMENT

Coal Age 77 (7), 159-165 (1972). Handling of acid mine drainage is discussed under the following topics: gravity flow and diversion; selecting pumps; planning pipeline; handling water; acid-formation basics; prevention and control; and treatment and disposal. OR 72-49

MD72-53 THE EFFECTS OF ATMOSPHERIC PRESSURES ON THE OXYGEN LEVEL IN A SEALED MINE

Moebs, N. N. and Chamberlain, C. E., U.S. Bur. Mines, RI 7606 (1972). 19 pp. The atmosphere in part of an air-sealed coal mine in southwestern Pennsylvania was monitored continuously through a drill hole for oxygen content to determine the effectiveness of sealing a mine against the entrance of air and the major force that caused the phenomenon of mine breathing through the overburden. The differential pressure across the seal and the barometric pressure on the outside also were recorded. A general correlation obtained between the oxygen level, differential pressure, and barometric pressure, indicates that changes in air pressure are the cause for periodic replenishment of the oxygen in the mine. Mine effluent quality was determined by conditions in many sections of the mine and could not be related to the oxygen level at the drill hole. (Authors' abstract) OR 72-33

MD72-54 ACID MINE DRAINAGE: A MATHEMATICAL MODEL

Morth, A. H. (1) and Smith, E. E. (2) [(1) Ohio Geol. Surv. and (2) Ohio State Univ.], Fourth Symp. Coal Mine Drainage Res., Pittsburgh, Pa. by Coal Ind. Advisory Comm. to ORSANCO (1972). 11 pp. A mathematical model of an acid mine drainage system has been developed for a drift mine. The model relates the rate of acid formation by pyrite oxidation to the rate of pollution discharge from the system. Input to the model includes a physical and chemical description of the system, together with day-to-day record of temperature and precipitation. The portion of the model used to calculate the oxidation rate of pyritic material is generally applicable. Calculation of oxidation product removal rates requires information on specific features of the system's hydrologic characteristics which are best determined from a few field observations. The model duplicates the seasonal pattern of acid mine drainage for the mine modeled. Calculated acid loads and drainage flows agree within 5 percent of the yearly values and within 20 percent of the monthly rates. (From authors' abstract) OR 72-8

MD72-55 PYRITIC SYSTEMS: A MATHEMATICAL MODEL

Morth, A. H., Smith, E. E., and Shumate, K. S., The Ohio State Univ. Res. Found., Rept. to EPA, Environ. Protection Technol. Ser. EPA-R2-72-002 (Nov. 1972). 171 pp. NTIS, PB-213 887. A mathematical model of an acid mine drainage system has been developed for underground mines. The model relates the rate of acid formation to the rate of pollution discharge from the system. The input to the model is a physical and chemical description of the system. Acid removal kinetics were related to three removal mechanisms: (1) leaching by water trickling downward through oxidized pyritic material, (2) flushing of oxidation products by movement of the water table, and (3) diffusion of oxidation products by continuous oxidation and adsorption of moisture. Underground mines for which drainage data were available were modeled to test the ability of the model to predict flow and acid load data from different mines. The model accurately predicts yearly flow and acid loads and duplicates seasonal patterns. (From authors' abstract) OR 72-59

MD72-56 REVERSE OSMOSIS - NEW SOLUTIONS AND NEW PROBLEMS

Nusbaum, I., Cruver, R. E., and Sleigh, J. H., Jr., Chem. Eng. Prog. 68 (1), 69-70 (1972). The value of reverse osmosis for treating many industrial aqueous wastes, and municipal waste waters is explained. At the EPA Mine Drainage Field Site at Norton, West Virginia reverse osmosis has been studied for three years. The water treated had total dissolved solids of approximately 2,500 mg/l and the product stream, a 75% water recovery, was described as suitable for almost any use with pH adjustment. OR 72-83

MD72-57 TREATMENT OF ACID MINE DRAINAGE

O'Brien, W. S., Ph.D. Thesis, W. Va. Univ., 1972. 380 pp. Univ. Microfilms, 72-26, 887. Acid mine drainage formation and treatment are reviewed and a mathematical

MD72-57 (continued)

model for mine water is developed. In testing the model, "a simple neutralization process is simulated to demonstrate that the model operates over all ranges of iron water compositions." OR 72-93

MD72-58 A NEW FILTRATION DEVICE FOR CONCENTRATING NEUTRALIZED AMD SLUDGE

Page, B. W. (1), Copley, M. J. (1), and Shackelford, J. M. (2) [(1) Aqua-Ion Corp. and (2) EPA, Washington, D.C.], Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 234-243. The permeable, vertically-hung, hose-type filter unit is one part of an acid mine drainage treatment system which also uses ion exchange. Synthetic mine water was used in this work. The treated mine water, neutralized by calcium carbonate and brought up to a pH of about 10 with lime, was pumped through the hose-filter. Sludge was compacted at the bottom of the hose and an essentially saturated solution of calcium sulfate filtered through it. Sulfate was removed by ion exchange and calcium removed by carbonation of the ion exchange effluent. This step resulted in a stream of potable water and calcium carbonate that could be used in the neutralization step. Some of the ion exchange stream was treated with lime and used to regenerate the ion exchanger. Treatment of the neutralized mine water was carried out at about 275 gal/hour at pump pressure of less than 19 psi and gave a filtrate containing less than 0.5 mg/l iron and a compacted sludge of about 25 percent solids. OR 72-17

MD72-59 MINE DRAINAGE POLLUTION PREVENTION AND ABATEMENT USING HYDROGEOLOGICAL AND GEOCHEMICAL SYSTEMS

Parizek, R. R. (1) and Tarr, E. G. (2) [(1) The Pa. State Univ. and (2) Knox, Bergman, Shearer Corp.], Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 56-82. The use of natural systems to treat and control formation of mine drainage is advocated as an alternative to building treatment plants. Hydrogeological systems indicate which of a number of diversion or water control methods will be of value in a particular situation. The discussion includes a comparison between mining updip and mining downdip; description of surface water diversion, factors involved in ground water diversion through wells connecting aquifers which are at different levels; and ways in which alkaline ground water can be used to neutralize acid drainage. OR 72-9

MD72-60 COMBINED TREATMENT OF MUNICIPAL WASTEWATER AND ACID MINE DRAINAGE

Pearson, F. H. and Nesbitt, J. B., Pa. State Univ., Inst. Res. Land Water Resour., Res. Publ. No. 73, Dec. 1972. 43 pp. NTIS, PB-222 936. Laboratory studies were carried out on actual acid mine drainages combined with municipal waste water from nearby sources. Best results occurred when iron of the acid mine drainage was in the ferrous state, and when the pH of the combined waters was adjusted to 8. Cost analyses showed that there is a limit to the distance that it is economical to pump the acid mine drainage. OR 72-87

MD72-61 LEACHATE QUALITY FROM ACIDIC MINE SPOIL FERTILIZED WITH LIQUID DIGESTED SEWAGE SLUDGE

Peterson, J. R. and Gschwind, J., J. Environ. Qual. 1 (4), 410-412 (1972). Laboratory studies of leachate from various sludge-spoil mixtures and from spoil alone showed that sludge would increase pH, reduce aluminum, iron, soluble salts and acidity, and increase ammonia nitrogen and total phosphorus. OR 72-91

MD72-62 HYDROCARBON EXTRACTION OF ACID MINE DRAINAGE

Powell, R. W., M.S. Thesis, Pa. State Univ., Dept. Chem. Eng., 1972. 107 pp. In the application of this well-known separation technique to treatment of acid mine drainage, n-heptane was chosen as the solvent from three hydrocarbons studied. It was found that at 518 F the extraction was carried out most efficiently and that

MD72-62 (continued)

there were no noticeable reactions or emulsion effects. A minimum of four stages was needed for 90 percent recovery of pure water at a solvent-to-feed ratio of 6.5 to 1. The economics of the process were discussed. OR 72-104

MD72-63 PRIORITY DETERMINATION PROCEDURE - FOR THE SELECTION OF POLLUTION ABATEMENT PROJECTS IN THE MONONGAHELA RIVER BASIN

Rivkin/Carson, Inc. with Arthur W. Edwards, Associates, Rept. to Appalachian Regional Comm. (March 1972). 107 pp. This report describes a method of drawing a "profile" of the subbasins of the Monongahela River as a criterion to determine the priority of pollution abatement projects. Both economic and water quality factors of the region are considered. The laws of the states in which the area lies are reviewed in an appendix. OR 72-42

MD72-64 EVALUATION OF WASTE WATERS FROM PETROLEUM AND COAL PROCESSING

Reid, G. W. and Streebin, L. E., Oklahoma Univ., Norman Res. Inst., Rept. to EPA, Office Res. Monitoring, Environ. Protection Technol. Ser. EPA-R2-72-001 (Dec. 1972). 205 pp. NTIS, PB-214 610. The coal section has detailed information on the coal industry and its problems, and includes a review of treatment processes for mine acids, and coal cleaning and handling processes. OR 72-68

MD72-65 BIOLOGICAL TREATMENT OF ACID MINE WATER

Rice, P. A. and Rabolini, F. (Syracuse Univ.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 293-306. A treatment process is proposed in which the sulfate in mine drainage is bacteriologically reduced to sulfide with the resulting recovery of elemental sulfur and removal of iron in sludge. Since process technology is well established for sulfur recovery by the Claus process, these laboratory studies are limited to defining the parameters for the action of *Desulfovibrio desulfricans*. Acid mine water must be neutralized before bacterial treatment because minimum pH for bacterial action is 5.5 and optimum pH is 7-7.5. An organic substrate is also necessary. Results show that both of these conditions can be met with sewage digester sludge. For the process to be economically feasible, the organic substrate should be a waste product that is available at little or no cost. OR 72-21

MD72-66 RECLAMATION AND MINE TIP DRAINAGE IN EUROPE

Riley, C. V. and Rinier, J. A. (Kent State Univ.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 1-14. British and western European, especially German, experience in reclaiming coal refuse piles is reviewed. OR 72-1

MD72-67 EVALUATION OF BULKHEAD SEALS

Scott, R. B. (Crown Mine Drainage Control Field Site, Rivesville, W. Va.), U.S. EPA, Office Res. Monitoring, Environ. Res. Center, Cincinnati, Ohio, Oct. 1972. 29 pp. In September 1969, the Norton Mine Drainage Field Site began to monitor mine seals previously installed by the Halliburton Company. Four kinds of seals were placed: (1) grouted limestone, (2) grouted cloth retainers placed in layers, (3) inner and outer sodium silicate cement walls with a grouted limestone aggregate or cement core, and (4) a permeable limestone aggregate seal. Diagrams illustrate each seal and tabulated data show the measurements taken during the evaluation. At the Clarksburg, West Virginia location, bulkheads significantly reduced discharge thereby reducing acid loads, iron and sulfate. The permeable type aggregate seal was more effective since seepage thru the seal was of better quality than leakage thru bulkhead seals. None of the discharges after sealing would meet the West Virginia or Pennsylvania discharge standards. OR 72-80

MD72-68 DESIGN OF OXIDATION SYSTEMS FOR MINE WATER DISCHARGES

Selmeczi, J. G. (Dravo Corporation), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 307-330. The author presents the theoretical considerations in ferrous iron oxidation and shows how they may be used as the basis for design of the treatment plant. Since the amount of dissolved oxygen in the water to be treated will affect the rate of ferrous iron oxidation above pH 4.5 various means of aerating mine water and conditions affecting solubility of oxygen in water are discussed in detail. OR 72-22

MD72-69 THE GROWTH OF *CHLORELLA VULGARIS* IN SEWAGE AND ACID MINE WATER

Skinner, W. F. and Keller, E. C., Jr. (W. Va. Univ., Dept. Biol.), Proc. W. Va. Acad. Sci. *44* (1), 49-56 (April 1972). This research was done to determine the effects of sewage, acid mine water and their interaction on the growth of the unicellular green alga *Chlorella vulgaris* (Pratt strain). The nutrient media were composed of sterile synthetic sewage and/or acid mine water diluted to the desired concentrations with a standard inorganic culture medium. Maximum growth was obtained with the 1/2 sewage treatment, the least growth occurred with 1/8 acid mine water plus 1/2 sewage treatment. High concentrations of sewage in combination with high concentrations of acid mine water inhibited algal growth. (From authors' abstract) OR 72-96

MD72-70 THE ADVANTAGE OF A CROWD FOR ACID WASTE LIQUORS

Smith, J. H., III (Bethlehem Steel Corp.), Mining Eng. *24* (12), 57-59 (1972). Personnel of the Homer Research Laboratories report that when settled solids from mine drainage treatment are recycled back through the treatment plant, the final sludge has significantly increased solids content and improved settling characteristics. OR 72-72

MD72-71 *AUFWUCHS* ACCRUAL IN STRIP-MINE LAKES

Stickney, R. R. and Campbell, R. S. (Univ. Mo.), J. Water Pollut. Contr. Fed. *44*, 2172-2177 (1972). The purpose of this study was to compare growth patterns of *Aufwuchs* in a series of strip-mine lakes with pH ranging from 3 to 8. The study was based on the rate of weight accrual of *Aufwuchs* on artificial substrates. Presumably the accrual rate is indicative of production. This rate was significantly greater in alkaline than in acid waters as shown by both estimates of accrual rate and data on the organic standing crop. (From authors' text) OR 72-64

MD72-72 DIE BAKTERIELLE OXYDATION VON PYRIT (BACTERIAL MEDIATION IN THE OXIDATION OF PYRITE)

Stumm-Zollinger, E. (Harvard Univ.), Arch. Mikrobiol. *83*, 110-119 (1972). (In German with English summary). The oxidation of pyrite by bacteria has been studied. Rate of reaction and factors affecting it are discussed. OR 72-43

MD72-73 CHRONIC EFFECT OF FERRIC HYDROXIDE ON CERTAIN SPECIES OF AQUATIC ANIMALS

Sykora, J. L., Smith, E. J., Shapiro, M. A., and Synak, M. (Univ. Pittsburgh), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 347-369. The effects of various concentrations of iron as suspensions of ferric hydroxide on the mortality, egg production, spawning and hatching of fathead minnows, brook trout, freshwater shrimp and caddisfly are reported. In summary, the authors conclude that "the most important effect of suspended iron on aquatic fauna is of physical nature, producing high turbidities which prevent fish from eating (in high concentrations) or exerting some effect on the most susceptible stages of the fish life cycle - eggs and hatched fry - in low concentrations." OR 72-26

MD72-74 EFFECT OF LIME NEUTRALIZED IRON HYDROXIDE SUSPENSIONS ON JUVENILE BROOK TROUT (SALVELINUS FONTINALIS, MITCHILL)

Sykora, J. L., Smith, E. J., and Synak, M. (Univ. Pittsburgh, Grad. School Public Health), Water Res. 6, 935-950 (1972). There was a definite trend in the size of young trout with increasing concentration of suspended ferric hydroxide, with the largest trout in 6 mg Fe per liter and in the control. The average growth rate computed for five different groups of fish revealed a sudden decline in growth of brook trout exposed to 12, 25, and 50 mg Fe 1^{-1}. It is assumed that impaired visibility due to high turbidity prevented the fish from feeding which in turn resulted in slow growth in high iron concentrations - 12, 25, and 50 mg Fe 1^{-1}. (From authors' abstract) OR 72-78

MD72-75 SIMULTANEOUS POLAROGRAPHIC DETERMINATION OF IRON (II) and IRON (III) COAL MINE WASTE WATER

Tackett, S. L. and Wieserman, L. F., Anal. Lett. 5 (9), 643-651 (1972). The method uses sodium carbonate-oxalic acid as an electrolyte. Samples were taken in the field and analysis done to measure how the two iron contents vary according to sampling locations. Near the source, the Fe(II) content was higher. Samples taken farther down the stream showed increases in Fe(III), decreases in Fe(II) and decreases in pH. As sampling moved farther from the source, Fe(III) decreased as it precipitated. OR 72-90

MD72-76 TENNESSEE VALLEY STREAMS: THEIR FISH, BOTTOM FAUNA, AND AQUATIC HABITAT, SEQUATCHIE RIVER DRAINAGE BASIN, JUNE 1970

U.S. TVA, Div. Forestry, Fisheries, and Wildlife Develop., Norris, Tenn., July 1972. 6 pp.+ Big Brush Creek is noted as having a low diversity index and standing crop of fish because of periodic acid mine drainage. Sampling stations are listed and described. There are tabulations of results of the fish and faunal sampling programs and of water quality analyses. OR 72-76

MD72-77 USE OF LATEX AS A SOIL SEALANT TO CONTROL ACID MINE DRAINAGE

Tolsma, J. and Johnson, A. N., Uniroyal, Inc., Rept. to EPA, Office Res. Monit., and Pa. Dept. Environ. Resour., Water Pollut. Contr. Res. Ser. 14010 EFK 06/72 (1972). 84 pp. NTIS, PB-213 040. A study was made to test the feasibility of using latex as a soil sealant to prevent water seepage into subterranean abandoned mines. A variety of latexes were screened in laboratory tests using reconstructed soil columns. The most promising latex (an SBR rubber latex) was then field tested on selected 1/4 acre plots near Lanse, Pennsylvania. In general the field tests confirmed the laboratory finding that latex does reduce the permeability of soil to water. However, the economics are not attractive and most of the latex is deposited in the top foot of soil where it is subject to damage by microbiological attack, frost and surface vegetation. (Authors' abstract) OR 72-50

MD72-78 PRIMARY PRODUCTIVITY IN RELATION TO CHEMICAL PARAMETERS IN CHEAT LAKE, WEST VIRGINIA

Volkmar, R. D. (W. Va. Univ., Dept. Biol.), Proc. W. Va. Acad. Sci. 44 (1), 14-22 (1972). In this study on the effect of acid mine water on phytoplankton in Cheat Lake, samples were taken from two backwater areas, Rubles Run and Morgan Run, and in the main lake near the dam. Detailed water analyses were run and the data are tabulated. Definite temperature profiles were noted in the Cheat Lake thermal readings. Primary productivity was correlated with the water chemistry and mineral acid was found to have a significant influence on carbon assimilation in the lake, but more study is needed to fully understand the relation of acidity to primary productivity. OR 72-99

MD72-79 THE USE OF AQUATIC PLANTS IN THE REHABILITATION OF ACID POLLUTED STREAMS

Wagner, R. H., Inst. Res. Land Water Resour., Pa. State Univ., Rept. to U.S. Office Water Resour. Res., Proj. No. A-025-PA, June 1972. 9 pp. NTIS, PB-213 507. This study was concerned chiefly with the general ecology of Eleocharis acicularis (L.) R. & S. and its relation to acid polluted streams. Growth was optimal in the pH range of 3.6 to 5.0 and inversely proportional to the phosphorus concentration. Other mineral factors appear to be unrelated to E. acicularis distribution. The adult plant also is able to grow at 32°C and overwinter in a vegetative state at 4°C. Under proper conditions of moisture or cold treatment, the seeds will germinate readily with a germination rate of 80%. (From author's abstract) OR 72-69

MD72-80 BIOLOGICAL CONTROL OF ACID MINE POLLUTION

Walsh, F. and Mitchell, R. (Harvard Univ.), J. Water Pollut. Contr. Fed. 44 (5), 763-768 (1972). An organism capable of catalyzing iron oxidation between pH 3.5 and 4.5 has been identified as a precursor of T. ferrooxidans. Three pollution control methods suggested are based on interfering with the activity of the precursor. OR 72-38

MD72-81 A pH-DEPENDENT SUCCESSION OF IRON BACTERIA

Walsh, F. and Mitchell, R., Environ. Sci. Technol. 6 (9), 809-812 (1972). A filamentous iron bacterium significantly catalyzes iron oxidation in the pH range 4.5-3.5. At pH greater than 4.5, abiotic iron oxidation proceeds rapidly. At pH less than 3.5, Thiobacillus ferrooxidans significantly catalyzes iron oxidation. The activity of the filamentous iron bacteria in this succession of events may directly affect the rate of acidity production in coal mine waters. (From authors' abstract) OR 72-97

MD72-82 WATER POLLUTION, FISH KILLS, AND STREAM LITTER INVESTIGATIONS 1972

Ohio Dept. Natural Resour., Div. Wildlife, Publ. 7, (undated). 27 pp. Results of investigations of pollution incidents are listed. Mine acids are the cause in several cases. OR 72-77

MD72-83 BENTHIC MACROINVERTEBRATE COMMUNITY STRUCTURE IN A STREAM RECEIVING ACID MINE DRAINAGE

Weed, C. E. (1) and Rutschky, C. W., III (2) [(1) Mansfield State College, Pa. (2) Pa. State Univ.], Proc. Pa. Acad. Sci. 46, 41-47 (1972). A survey of benthic organisms in the Tioga River, Pennsylvania was carried out May through November 1970. Results of sampling stations above and below drainage from mined areas showed that the number and diversity of the organisms are related to the acidity, sulfate and iron in the water and to the accumulation of ferric hydroxide deposits on the stream bed. OR 72-94

MD72-84 KINETICS OF LIMESTONE DISSOLUTION BY ACID WASTE WATERS

Wentzler, T. H. and Aplan, F. F., Proc. AIME Environ. Control Symp., San Francisco, Cal. (1972). pp 513-523. This study was conducted to learn the kinetics of limestone dissolution in the presence and absence of inhibiting calcium sulfate and iron hydroxide precipitates. The rate of limestone dissolution was found to be first order with respect to the hydrogen ion concentration, and data indicate that limestone dissolution is transport controlled. (From authors' abstract) OR 72-95

MD72-85 CORROSION OF NAVIGATION FACILITIES

West, Col. E. C. (U.S. Army Engineer District, Pgh.), Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 344-346. The empirical results of mine drainage pollution on locks and dams of the upper Ohio River and its tributaries are described. Various kinds of protection being tested include protective painting, use of non-corrosive materials and cathodic protection. OR 72-25

MD72-86 MINE DRAINAGE POLLUTION CONTROL BY REVERSE OSMOSIS

Wilmoth, R. C. and Hill, R. D. (Nat. Environ. Res. Center, Cincinnati, Ohio), SME of AIME Fall Meet., Birmingham, Ala. (1972). Preprint No. 72F343. 28 pp. This paper reviews the research sponsored and conducted by EPA since 1966 on the use of reverse osmosis for treatment of acid mine drainage. OR 72-52

MD72-87 TREATMENT OF FERROUS IRON ACID MINE DRAINAGE BY REVERSE OSMOSIS

Wilmoth, R. C. (1), Mason, D. G. (2), and Gupta, M. K. (2) [(1) EPA, Norton, W. Va. and (2) Rex Chainbelt, Inc.], Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 115-156. This project was undertaken to determine whether the difficulty encountered in a previous study of reverse osmosis treatment using a tubular system was the result of iron fouling of the membrane. Three treatment systems, tubular, spiral wound, and hollow fiber, were used with the same water treated previously, a discharge with 80 mg/l total iron, 68 mg/l ferrous iron, and 800 mg/l sulfate. Since laboratory investigation showed that bacterial oxidation of iron and resulting ferric hydroxide precipitation occurred, ultraviolet light to kill the iron oxidizing bacteria was installed as part of each of the three treatment systems. The ultraviolet light prevented bacterial iron oxidation as did an acid injection to lower the pH of the feed to 2.9. Calcium sulfate fouling occurred as product stream recovery increased over 75 percent. The productivity of the tubular system was lower and its initial cost higher than the hollow fiber and the spiral wound systems. OR 72-13

MD72-88 COMBINATION LIMESTONE-LIME TREATMENT OF ACID MINE DRAINAGE

Wilmoth, R. C. (1), Scott, R. B. (1), and Hill, R. D. (2) [(1) Norton Mine Drainage Field Site, W. Va. and (2) EPA, Ohio], Fourth Symp. Coal Mine Drainage Res. Preprints, Pittsburgh, Pa. (1972). pp 244-265. The treatment process developed from the laboratory batch testing and pilot plant tests reported in this paper is carried out in two stages. Mine drainage is first neutralized by limestone to a pH of about 4 with retention time of 20-30 minutes. Then the pH can be raised to any desired level with lime. Both lime and limestone used alone were compared to various combinations of the two reagents. Quality of effluents from the different treatments was comparable. There was a higher percentage of sludge solids and a lower sludge volume produced by combination treatment than by lime treatment. However these sludge characteristics were less favorable than those from sludge produced by limestone treatment. Cost of materials for the combination treatment of ferric iron water is shown to be 25 percent less than the cost of either lime or limestone neutralization. Costs projected for treatment of ferrous iron waters indicate that the combination process has an economic advantage. OR 72-18

MD72-89 THE LIFE HISTORY OF THE ALDERFLY, SIALIS AEQUALIS BANKS, IN AN ACID MINE STREAM

Woodrum, J. E. and Tarter, D. C., Amer. Midl. Natur. 89 (2), 360-368 (1972). The life history of the alderfly, *Sialis aequalis* Banks, was studied intensively in an acid mine stream, Camp Creek of Twelvepole Creek, Wayne Co., West Virginia, between July 1970 and June 1971. (From authors' abstract) OR 72-89

MD72-90 CONVERSION OF COAL-MINE DRAINAGE TO POTABLE WATER BY ION EXCHANGE

Zabban, W., Fithian, T., and Maneval, D. R., J. Am. Water Works Assoc. 64, 775-780 (Nov. 1972). The following water treatment methods and their possible application to treatment of acid mine drainage are reviewed: flash distillation, ion exchange, reverse osmosis, electrodialysis, and refrigeration. The ion exchange treatment plant for water supply in Smith Township, southwestern Pennsylvania is described. The initial operating experience, in 1971, mainly of the "shakedown-type" is discussed. OR 72-57

MD72-91 CONVERTING AMD TO POTABLE WATER BY ION EXCHANGE TREATMENT

Zabban, W. (1), Fithian, T. (1), and Maneval, D. R. (2) [(1) The Chester Engineers, Inc. and (2) Appalachian Regional Comm.], Coal Age 77 (7), 107-111 (1972). Mine drainage flows through limestone or calcareous shales to the reservoir for water supply for Smith Township in southwestern Pennsylvania. The resulting raw water is characterized by pH of 6.5-8.4, 1500-2000 mg/l total dissolved solids, and 400 mg/l sulfate. The ion exchange resin treatment, termed the SUL-biSUL process, used to improve the water quality is described. Pilot plant studies have been carried out on "short-term duration" while mechanical problems were being solved. The results obtained indicate that the method can be used economically for continuous operation. OR 72-48

MD72-92 REVEGETATION AUGMENTATION BY REUSE OF TREATED ACTIVE SURFACE MINE DRAINAGE - A FEASIBILITY STUDY

Zaval, F. J. and Robins, J. D., Cyrus Wm. Rice Div. - NUS Corp., Rept. to EPA, Environ. Protection Technol. Ser. EPA-R2-72-119 (Nov. 1972). 147 pp. NTIS, PB-214 458. The objective of this study was to determine the feasibility of conducting a full-scale demonstration project on the use of neutralized acid mine drainage to irrigate new vegetative cover on regraded spoil banks. A site in the Western Coal Field of Kentucky, near Madisonville, was evaluated as the most suitable for implementation of the revegetation concept. Based upon the analyses performed, a flow diagram of a suitable limestone neutralization facility was developed. Four irrigation techniques were evaluated before a high pressure spray system was selected as the most practical means of delivering the treated drainage. Pertinent cost estimates were developed for the construction, installation and operation of the entire system at the selected demonstration site. (From authors' abstract) OR 72-63

MD73-1 HYDROLOGY OF A WATERSHED CONTAINING FLOOD-CONTROL RESERVOIRS AND COAL SURFACE-MINING ACTIVITY, SOUTHWESTERN INDIANA

Agnew, A. F. and Corbett, D. M. (Ind. Univ.), in "Ecology and Reclamation of Devastated Land," Vol. 1, R. J. Hutnik and G. Davis, Eds., New York: Gordon and Breach, 1973. Paper II-3. pp 159-173. Hydrologic studies of Busseron Creek watershed are reported. Monitoring water quality during normal, high, and low flow and during "flush out" has shown the effects of flushouts on chemical quality of creek water. OR 73-80

MD73-2 ACID MINE DRAINAGE CONTROL METHODS

Akers, D. J., Jr. and Lawrence, W. F., W. Va. Univ., Coal Res. Bur., Morgantown, W. Va., Rept. No. 86, 1973. 10 pp. (Presented SME of AIME, Chicago, Ill., Feb. 1973). The causes of acid formation in the mine and the processes of prevention and control are discussed. Restriction of water entry is a major approach and control of the acid forming reaction is essential. A novel method of reducing the oxygen-pyrite contact being examined by Island Creek Coal Company is mining in a nitrogen, nitrogen and methane, or all methane atmosphere. Conventional treatment methods discussed are neutralization, reverse osmosis, and ion exchange. There is a list of references. OR 73-45

MD73-3 DEWATERING OF MINE DRAINAGE SLUDGE - PHASE II

Akers, D. J., Jr. and Moss, E. A., Coal Res. Bur., W. Va. Univ., Rept. to EPA, Environ. Protection Technol. Ser. EPA-R2-73-169 (Feb. 1973). 152 pp. NTIS, PB-221 145. Sludges from four lime or limestone treatment plants were used in this study of the dewatering and conditioning characteristics of coal mine drainage sludges. In the sampling program, carried out over 17 months, chemical analyses were made on the acid mine feed water and on the sludges from the treatment plants. Settling characteristics and solid content of the sludges were also evaluated. The conditioning methods studied were freezing, use of flocculants and use of filter aids. The six dewatering systems evaluated were: conventional rotary vacuum filtration; rotary precoat vacuum filtration; pressure filtration; porous bed filtration; and centrifugation. No single dewatering system was found best for all acid mine drainage sludges. However, on the basis of cost, the most promising acid mine drainage sludge dewatering techniques appear to be centrifugation, conventional rotary vacuum filtration, and rotary precoat vacuum filtration. (Report abstract adapted) OR 73-7

MD73-4 THE USE OF ERTS-1 MSS DATA FOR MAPPING STRIP MINES AND ACID MINE DRAINAGE IN PENNSYLVANIA

Alexander, S. S., Dein, J., and Gold, D. P. (Pa. State Univ., Office Remote Sensing Earth Resour.), Symp. on Significant Results Obtained from Earth Resources Technical Satellite-1 Vol. 1 Technical Presentation Section A: Natl. Aeronautics and Space Admin. Rept. NASA SP-327 (1973). pp 569-575. Paper E3. The use of digital processing of ERTS-1 MSS data for areas around the West Branch of the Susquehanna River permits identification of stripped areas including ones that are not discernible from visual analysis of ERTS-1 imagery. Preliminary results indicate that ERTS data can be used to monitor not only the total extent of stripping in given areas but also the effectiveness of reclamation and pollution abatement procedures. OR 73-69

MD73-5 ANALYSIS OF POLLUTION CONTROL COSTS

Michael Baker, Jr., Inc., Rept. to Appalachian Regional Comm., Feb. 1973. 436 pp. Also published as Doyle, F. J., Bhatt, G., and Rapp, J. R., Michael Baker, Jr., Inc., Rept. to EPA, 670/2-74-009 (1974). NTIS, PB-233 026/4WP. The purpose of this publication is to provide data which will enable the Commission to estimate costs of pollution abatement in the Monongahela River Basin. Pollution both from coal mining and from non-coal sources is considered. Abatement methods discussed include mine

MD73-5 (continued)

sealing, stream diversion, and mine drainage treatment. OR 73-8, OR 74-11

MD73-6 ACID MINE DRAINAGE - THE PROBLEM, THE TREATMENT, THE COST

Aston, W. M., Green Lands 3 (3), 14-15 (1973). This article reviews work on the mine drainage problem at the Water Research Institute at West Virginia University. Biological treatment, neutralization, and reverse osmosis, as well as costs of treatment are discussed. OR 73-21

MD73-7 MICROBIOLOGICAL FACTOR IN ACID MINE DRAINAGE FORMATION: PART II - FURTHER OBSERVATIONS FROM A PILOT PLANT STUDY

Baker, R. A. and Wilshire, A. G., Sci. Total Environ. 1, 411-426 (1972/1973). This study examined the effect of the organisms *Ferrobacillus ferrooxidans*, *Ferrobacillus sulfooxidans* and *Thiobacillus thiooxidans* in the formation of acid mine drainage from pyritic mineral associated with coal mining. Under aerobic conditions, acidity, ferrous and total iron and sulfate concentrations are zero order with respect to flow expressed in reciprocal time units and much greater than under non-aerobic conditions. Total acidity is lower for seeded than for non-seeded aerobic conditions at higher retention times. (From authors' abstract) OR 73-46

MD73-8 SOIL AS A MEDIUM FOR THE RENOVATION OF ACID MINE DRAINAGE WATER

Beers, W. F., Jr., M.S. Thesis, Pa. State Univ., Dec. 1973. 145 pp. Also, Ciolkosz, E. J., Kardos, L. T., and Beers, W. F., Pa. State Univ., Inst. Res. Land Water Resour., Res. Proj. Tech. Compl. Rept. to Office Water Resour. Res., Dec. 1973. 135 pp. NTIS, PB-228 868. This study was done to determine the ability of Rayne silt loam and Guernsey silty clay loam soils to renovate acid mine water and to determine the effect of various soil properties on acid mine water. Soil samples came from the University Soil Characterization Laboratory. Acid water came from the University mine drainage treatment facility at Hollywood (Clearfield County), Pennsylvania. Of the soil properties studied, soil pH, $CaCO_3$ and Cation-Exchange Capacity (CEC) were found to be the most influential in the renovation of acid mine water. (Adapted from text) OR 73-54

MD73-9 INVESTIGATION OF ACID MINE DRAINAGE EFFECTS ON RESERVOIR FISHERY POPULATIONS

Benson, A., W. Va. Univ., Final Rept. to Bur. Sport Fisheries and Wildlife, U.S. Dept. Int., Contract No. 14-16-0005-3034, 1973. 135 pp. Tygart Lake, W. Va., a multiple-use reservoir, part of the upper Ohio River basin flood control system, is in a major coal mining area. This study was carried out in 1966-1967 to determine the relation between acid conditions and fish population of the lake. Data collected at a number of sampling stations include water temperature, turbidity, pH, and acidity, and fish census. Comparison with reservoirs having similar drawdown regimes indicates that the acidity of Tygart Lake results in a much lower fish population. OR 73-77

MD73-10 ECONOMICS OF COAL MINE DRAINAGE TREATMENT

Bhatt, H. G. (Michael Baker, Jr., Inc., Beaver, Pa.), Presented, Seminar on Design of Coal Mine Drainage Treatment Facilities, Pa. State Univ., University Park, Pa., November 12-14, 1973. 113 pp. Also published in Eng. Ext. Ser. No. 145, Purdue Univ., Proc. Ind. Waste Conf., 1974. pp 686-703. This seminar presentation is based on the Michael Baker, Jr. report to Appalachian Regional Commission, "Analysis of Pollution Control Costs." OR 73-34

MD73-11 WATER QUALITY MAINTENANCE

Boettger, T. E. and Koza, T. A., Pa. Bar Assoc. Quart., 196-202 (January 1973).

MD73-11 (continued)

The legislative and judicial background of Pennsylvania's regulation of acid mine drainage is reviewed. OR 73-58

MD73-12 COAL AND COAL MINE DRAINAGE

Boyer, J. F. and Gleason, V. E. (Bitum. Coal Res., Inc.), J. Water Pollut. Contr. Fed. 45 (6), 1179-1184 (1973). There are 58 references in this review of the literature of 1972. Topics covered include pyrite oxidation, effects of acid drainage and its components on aquatic animals and organisms, and controlling and treating acid mine drainage. OR 73-16

MD73-13 LOWER pH LIMIT FOR THE EXISTENCE OF BLUE-GREEN ALGAE: EVOLUTIONARY AND ECOLOGICAL IMPLICATIONS

Brock, T. D. (Univ. Wis.), Science 179 (4072), 480-483 (1973). Environments affected by acid mine drainage are among those where absence of the algae was confirmed. OR 73-25

MD73-14 FISHERY MANAGEMENT IN STRIP MINE LAKES

Burner, C. C. (Fish Wildlife Serv., USDI), Natl. Coal Assoc./Bitum. Coal Res., Inc., First Res. Applied Technol. Symp. Mined-Land Reclamation Preprints, Pittsburgh, Pa. (1973). pp 304-318. A study of ten surface mine lakes in Kansas and six in Indiana has demonstrated that surface mine lakes can support good quality sport fishery. Fish population can be established in lakes that have drainage from a fairly large watershed instead of only adjacent spoil banks; have an area greater than a half an acre; have a depth of over five feet; and a pH no less than 6. Fish stocking guidelines for these waters are given and suggestions are made of combinations of species and the conditions under which they should be used. OR 73-81

MD73-15 FISH AND FOOD ORGANISMS IN ACID MINE WATERS OF PENNSYLVANIA

Butler, R. L., Cooper, E. L., Hales, D. C., Wagner, C. C., Kimmel, W. G., and Crawford, J. K., Pa. State Univ., Rept. to EPA, Ecological Res. Ser. EPA-R3-73-032 (Feb. 1973). 158 pp. NTIS, PB-221 515. Common fish species normally distributed over several watersheds were absent where there was severe acid mine drainage. Ten species exhibited some tolerance to acid mine drainage (values of pH 5.5 or less). All five aquatic insect species survived exposure for four days to pH levels from 6.5 to 4.0. The 96-hour TLm values ranged from 3.31 for the most sensitive animal, Stenonema sp., to 1.72 for the most tolerant insect, Nigronia fasciata. (From authors' abstract) OR 73-15

MD73-16 AN ECOLOGICAL SURVEY OF THE WEST FORK OF THE OBEY RIVER, TENNESSEE WITH EMPHASIS ON THE EFFECTS OF ACID MINE DRAINAGE

Carrithers, R. B. and Bulow, F. J. (Tenn. Technol. Univ.), J. Tenn. Acad. Sci. 48 (2), 65-72 (1973). This study was a one-year survey to determine water quality, aquatic and fish population. A secondary objective was to determine the effects of acid mine drainage from a small tributary stream. Thirteen water quality parameters and 25 invertebrate families and 29 species of fish were monitored at six stations. Damage to fish population by acid mine drainage is through deterioration of the stream bottom. This condition can smother fish eggs and disrupt food availability. Natural productivity of the West Fork did not appear to be significantly reduced by acid mine drainage, but damage was done to the small section directly below the polluted tributary. OR 73-50

MD73-17 STRIP MINE RECLAMATION IN ILLINOIS

Carter, R. P., Zimmerman, R. E., and Kennedy, A. S., Argonne National Laboratory, Energy and Environ. Studies Div., Rept. to Ill. Inst. Environ. Qual., Dec. 1973.

MD73-17 (continued)

296 pp. A survey of lands affected by surface mining and by coal refuse piles before the passage of legislation requiring reclamation is the basis for this comprehensive study. Water quality data show that the Kaskasia, Big Muddy, and Saline are the major Illinois rivers in which significant mine-related pollution occurs. Water treatment costs and reclamation costs are presented. There is also an analysis of tax revenue over a number of years from representative parcels of land. OR 73-38

MD73-18 CHARACTERIZATION OF STRIP-MINE DRAINAGE BY PYRITE GRAIN SIZE AND CHEMICAL QUALITY OF EXISTING GROUNDWATER

Caruccio, F. T., in "Ecology and Reclamation of Devastated Land," Vol. 1, R. J. Hutnik and G. Davis, Ed., New York: Gordon and Breach, 1973. pp 193-226. This paper was presented at the 1969 International Symposium on the Ecology and Revegetation of Drastically Disturbed Areas and gives a continuation of work reported previously. OR 73-42

MD73-19 INVESTIGATION OF USE OF GEL MATERIAL FOR MINE SEALING

Chung, N. K., Dravo Corp., Rept. to EPA, Environ. Protection Technol. Ser. EPA-R2-73-135 (Jan. 1973). 67 pp. NTIS, PB-221 247. Laboratory testing of commercially available chemical grouts was conducted to evaluate their potential, with a cheap filler, for remote sealing of mine voids. A slurry mix of an acrylamide grout with flyash or mine refuse as a filler produced a strong controllable gel which resisted chemical attack in the laboratory over an eleven week exposure period. An attempt was made to apply the selected grout slurry through a borehole from the surface, forming the seal by controlling of setting time and distribution of the slurry without the use of retaining bulk heads. Application to a mine entry with high flow was not successful, although the technique may be applicable in dry or low flow situations. (Author's abstract adapted) OR 73-2

MD73-20 COAL MINE DRAINAGE IN THE SUSQUEHANNA RIVER BASIN

Skelly and Loy, Engineers, Consultants, Rept. to Susquehanna River Basin Comm., Sept. 1973. 297 pp. This publication updates and expands upon the 1968 report titled, "Mine Drainage in the Susquehanna River Basin" by the Federal Water Pollution Control Administration. Coal mine drainage water quality data for all affected streams in the basin are compiled. Factors discussed in detail include topography and climate, water use, sedimentation, mine drainage impact, benefits, and abatement measures. All tributaries in the bituminous and anthracite regions are also described fully. A detailed table shows benefits and costs associated with land and stream restoration. OR 73-61

MD73-21 COAL MINE DRAINAGE IN THE SUSQUEHANNA RIVER BASIN - EXECUTIVE SUMMARY

Skelly and Loy, Engineers, Consultants, Rept. to Susquehanna River Basin Comm., Sept. 1973. 49 pp. This summary includes the significant information on the impact of mine drainage on the rivers and streams in the Susquehanna River Basin, the abatement measures recommended, and the projected costs and benefits. OR 73-62

MD73-22 EFFECTS OF STRIP MINING ON THE HYDROLOGY OF SMALL MOUNTAIN WATERSHEDS IN APPALACHIA

Curtis, W. R. (Northeastern Forest Expt. Sta., USDA), in "Ecology and Reclamation of Devastated Land," Vol. 1, R. J. Hutnik and G. Davis, Eds., New York: Gordon and Breach, 1973. Paper II-2. pp 145-157. In eastern Kentucky, six subdrainages have been instrumented to record pre-mining conditions, changes during active mining operations, and the rate of recovery after mining. Stream turbidity and peak flows increase during mining, but on one subdrainage, turbidity returned to near pre-mining condition within about 6 months after mining. Storm runoff durations

MD73-22 (continued)

apparently do not change. Sulfate and magnesium in the streamflow have increased since mining. (From author's abstract) OR 73-82

MD73-23 DEBRIS BASIN CAPACITY NEEDS BASED ON MEASURED SEDIMENT ACCUMULATION FROM STRIP-MINED AREAS IN EASTERN KENTUCKY

Davis, J. R. and Hines, B. J. (Soil Conservation Ser., USDA), Natl. Coal Assoc./Bitum. Coal Res., Inc., First Res. Applied Technol. Symp. Mined-Land Reclamation Preprints, Pittsburgh, Pa. (1973). pp 260-276. Accumulations in some sediment debris basins less than one year old indicated that sediment yield of 0.28 acre-feet per acre of disturbed land could be expected for a three-year design period. It was assumed, based on research experience, that in three years a vegetative cover could be developed that would effectively control erosion. The engineering standard for basin construction, which was developed by the Soil Conservation Service, is appended to this paper. OR 73-83

MD73-24 DETERMINATION OF ESTIMATED MEAN MINE WATER QUANTITY AND QUALITY FROM IMPERFECT DATA AND HISTORICAL RECORDS - VOL. I-IV

Environ. Qual. Systems, Inc., Rept. to Appalachian Regional Comm., Jan. 1973. 4 volumes (Vol I - 166 pp.; Vol. II-IV - computer printouts). This report is part of the work done to carry out one recommendation of the 1971 Enforcement Conference on the Monongahela River and Its Tributaries: "develop methods to assign priorities to areas or subbasins that are to receive abatement measures." As nearly as can be determined, all of the raw data which exists for the 14 standard mines which were used in the analysis and for all of the 2,298 sources of mine drainage in the Monongahela River Basin have been brought together for the first time in one place. Volume I discusses the data, describes the mathematical modeling technique and presents results and summaries of results. Titles of other volumes are Volume II - "Results of Standard Mine Data Analyses;" Volume III (4 sections) - "Synthesized NSS (non-standard sources) Time-Load Profiles;" and Volume IV - "Source Rankings by Acidity Load." OR 73-14

MD73-25 RECLAMATION METHODS TO PREVENT WATER POLLUTION IN THE MORAVA RIVER WATERSHED

Draskovic, D. (Chamber of Economy, Kraljevo, Yugoslavia), in "Ecology and Reclamation of Devastated Land," Vol. 2, R. J. Hutnik and G. Davis, Eds., New York: Gordon and Breach, 1973. Paper VII-2. pp 361-378. Reclamation methods to prevent soil erosion are emphasized in this paper. OR 73-84

MD73-26 ECONOMIC IMPLICATIONS OF STRIP MINING LEGISLATION: THE SMALL FIRMS

Dreese, G. R. and Bryant, H. L., Soc. of Mining Eng. AIME Ann. Meet., Chicago, Ill., Feb. 25-March 1, 1973. Preprint No. 73F15. 26 pp. Costs and production figures are given to show the economic impact of reclamation and pollution control legislation in Ohio on large and small mining companies. From the experience of a small, typical surface mine, the conclusion is drawn that "only the most efficient and therefore probably the largest firms will be able to remain profitable under increasingly rigid mining legislation." Confirming this, the trend toward bigger firms in the coal industry is noted. OR 73-26

MD73-27 THE ECONOMIC IMPACT OF PUBLIC POLICY ON THE APPALACHIAN COAL INDUSTRY AND THE REGIONAL ECONOMY: VOL. II - THE IMPACT OF ENVIRONMENTAL AND OTHER POLICIES ON THE APPALACHIAN COAL INDUSTRY

Charles River Associates, Inc., Rept. No. CRA 173-22 to Appalachian Regional Comm., Jan. 1973. 495 pp. This report includes sections on water pollution from coal, mines in Appalachia, and on technology of acid mine drainage control. OR 73-27

MD73-28 EVALUATION OF POLLUTION ABATEMENT TECHNIQUES APPLICABLE TO LOST CREEK AND BROWN'S CREEK WATERSHED, WEST VIRGINIA

Ackenheil & Associates Geo Systems, Inc., Pittsburgh, Pa., Rept. to Appalachian Regional Commission, Washington, D.C., (undated). 71 pp.+ Four major drainage sources identified within the watershed discharge 600 lbs/day iron, and a combined acid load of 4800 lbs/day. Costs and benefits are considered for volume reduction methods and for several treatment methods including lime neutralization, ion exchange, and reverse osmosis. Water quality data on acidity, alkalinity, aluminum, sulfate, iron, and manganese are given for a number of sampling stations. The abatement plan recommended consists of surface reclamation at two sites and lime neutralization plants at two other locations. OR 73-33

MD73-29 FEASIBILITY STUDY LAKE HOPE MINE DRAINAGE DEMONSTRATION PROJECT

Ohio Dept. Natural Resour., Rept. to EPA, Environ. Protection Technol. Ser. EPA-R2-73-151 (March 1973). 97 pp. NTIS, PB-227 343. The feasibility of demonstrating refuse pile disposal and mine sealing in the Lake Hope area in Vinton County, Ohio is evaluated. There were 107 mine openings with the total acid discharge of over 700,000 lbs/year. The recommended program consisted of burying some of the refuse and sealing of the mine openings. At the present time Lake Hope pH is between 4.0 and 5.0. Final figure is expected to be 6.0 to 7.0 pH. Expansive concrete seals or plain concrete plugs were used for sealing. Water quality data from the surveillance program are included. OR 73-5

MD73-30 FEDERAL AND STATE EFFORTS TO CONTROL WATER POLLUTION CAUSED BY ACID DRAINAGE FROM MINES

Rept. by the Comptroller General of the United States, to the Conservation and Natural Resources Subcomm., Comm. Govern. Operations, U.S. House Representatives, B-177011 (Aug. 14, 1973). 61 pp. The mine drainage projects discussed include programs active and completed of EPA, Department of the Interior, Department of Agriculture, Corps of Engineers, and the Appalachian Regional Commission, from 1967 through 1972. Total costs, including the federal expenditures, are given. OR 73-66

MD73-31 TREATMENT OF FERROUS ACID MINE DRAINAGE WITH ACTIVATED CARBON

Ford, C. T. and Boyer, J. F., Jr., Bituminous Coal Res., Inc., Rept. to EPA, Environ. Protection Technol. Ser. EPA-R2-73-150 (Jan. 1973). 123 pp. NTIS, PB-219 826. The following variables influence the removal of iron with activated carbon: (a) amount and particle size of the carbon; (b) pH, flow rate, concentration of iron, temperature, and total ionic strength of the water; and (c) aeration rate. Adsorption as well as oxidation are the mechanisms involved in iron removal by this process. An evaluation of this process indicated technical feasibility which would permit acid mine drainage neutralization using an inexpensive reagent, such as limestone. The major disadvantage is the cost of the activated carbons since they are rendered inactive after relatively short use by apparently irreversible adsorption of iron. (From authors' abstract) OR 73-9

MD73-32 EVALUATION OF POLLUTION ABATEMENT PROCEDURES, MORAINE STATE PARK

Foreman, J. W. and McLean, D. C., Gwin, Dobson & Foreman, Inc., Rept. to U.S. EPA, Environ. Protection Technol. Ser. EPA-R2-73-140 (Jan. 1973). 71 pp. NTIS, PB-221 337. Surface mine reclamation, underground mine sealing, grouting, surface sealing, refuse pile removal, and oil and gas well plugging were carried out to prevent mine drainage pollution of Lake Arthur which was formed in the park by impounding the waters of Muddy Creek. Each separate abatement project is described and project costs are shown to vary widely. Analyses of water quality in Muddy Creek and in Lake Arthur are reported and indicate the benefits from the various abatement methods. OR 73-3

MD73-33 TRACING GROUND WATER BY GEOPHYSICAL METHODS

Greenfield, R. J. and Stoyer, C. H. (Pa. State Univ.), SME Fall Meet. and Exhibit, Pittsburgh, Pa., 1973. 73-F-346. 16 pp. Also published as "Monitoring groundwater contamination with geophysical methods," Trans. AIME 260, 20-23 (1976). Direct current electrical resistivity, and electromagnetic induction (E-M) were used to study the movement of highly conductive ground water at a field site in Kylertown, Clearfield County, Pa. Results of the two methods were comparable but E-M could be carried out much more quickly. OR 73-30

MD73-34 REGRESSION TECHNIQUES FOR ESTIMATION OF SULFATE IN STREAMS DRAINING AN AREA AFFECTED BY COAL MINING

Grubb, H. F. and Ryder, P. D. (U.S. Geol. Surv.), Proc. 3rd Ann. Environ. Eng. & Sci. Conf., Louisville, Ky. (1973). pp 129-137. This paper describes the development of a regression equation which gives the relationship between specific electrical conductance and sulfate concentration. Coefficients for the formula ($Y = a + bX$) were determined using data from 465 chemical analyses made over a 17-year period at the stream gaging station at Olney, Kentucky. This formula makes it possible to monitor long term effects of coal mining on stream water chemistry with specific conductance measurements and a limited number of chemical analyses. OR 73-63

MD73-35 HYDROGEOLOGY OF THE FORMATION AND NEUTRALIZATION OF ACID WATERS DRAINING FROM UNDERGROUND COAL MINES OF WESTERN MARYLAND

Hollyday, E. F. and McKenzie, S. W., Md. Geol. Surv., Rept. Invest. No. 20, 1973. 50 pp. The flows from 18 underground mines for which mine maps are available in the bituminous coal basins of western Maryland were measured, and water samples were collected for determination of 27 major dissolved constituents and chemical properties and 28 minor elements. Natural neutralization is taking place in the underground environment and the most nearly neutralized acid mine drainage is associated with flow from an upper mine to a lower mine through the intervening rock strata. (From authors' abstract) OR 73-65

MD73-36 MICRO-ECOSYSTEMS SIMULATION OF PRIMARY PRODUCTION IN THERMAL AND ACID MINE WATER LOADINGS RELATED TO WATER USE OF THE MONONGAHELA RIVER

Keller, E. C., Jr. et al. (W. Va. Univ.), Water Res. Inst., Completion Rept. B-001-WVA, W. Va. Univ. Bull., 1973. 442 pp. This program was set up to study the effects of acid mine water, thermal loading and sewage on algal population growth. Both laboratory and field studies were carried out. Field studies were made in areas of the Monongahela River that included an acid tributary, and two power plants, one of which has a Primary Sewage Treatment Plant located adjacent to it. Water temperature, chemical parameters, BOD, turbidity, Diversity Index and Biomass were measured and microbiological analyses were run. Information about the two power plant sites was compared by evaluating the correlation of 13 independent variables with the biomass, the dependent variable. Variables which are components of acid mine drainage are found to have the most significant effect on the level of biomass. OR 73-64

MD73-37 SODIUM HYDROXIDE TREATMENT OF ACID MINE DRAINAGE

Kennedy, J. L., U.S. EPA, Crown Mine Drainage Field Site, Rivesville, W. Va., Feb. 1973. 6 pp.+ A 10% concentration of sodium hydroxide was used in a treatment project done at the Norton Mine Drainage Field Site in West Virginia. Cost proved to be considerably higher than that for lime, limestone, or soda ash. Sludge volume averaged 2% of the original volume treated. OR 73-6

MD73-38 ORGANIC WASTES AS A MEANS OF ACCELERATING RECOVERY OF ACID STRIP-MINE LAKES

King, D. L. and Simmler, J. J., Univ. Mo., Water Resour. Center, Completion Rept. to U.S. Dept. Int., Office Water Resour. Res., Feb. 20, 1973. 65 pp. The buffering action of iron and aluminum in retarding the recovery of surface mine lakes was studied in the laboratory. Addition of sewage as a source of organic carbon for sulfate reducing bacteria in the simulated lake environment showed that activity of the bacteria could be enhanced to accelerate the recovery of acid lakes. OR 73-12

MD73-39 CONTROL OF MINE DRAINAGE FROM COAL MINE MINERAL WASTES: PHASE II - POLLUTION ABATEMENT AND MONITORING

Kosowski, Z. V., Consolidation Coal Co., Rept. to EPA, Environ. Protection Technol. Ser. EPA-R2-73-230 (May 1973). 83 pp. NTIS, PB-222 252. This final report gives the result of an extensive project on mine drainage control and reclamation of the New Kathleen Mine Site. Tests showed that a one-foot soil cover controlled acid production as well as a 3-foot cover. A number of vegetative covers were tested using standard agricultural techniques. Maintenance on the pile the first year showed that it is important to reseed and recover bare spots. Acid production was reduced from 198 lbs/acre/day to 16 lbs/acre/day. OR 73-13

MD73-40 METHOD FOR TREATING ACID WATER CONTAINING METALLIC VALUES

Kostenbader, P. D. (to Bethlehem Steel Corp.), U.S. Pat. 3,738,932 (June 12, 1973). 7 pp. This patent outlines a method of treating acid water such as mine water and pickle liquor with an alkali slurry of high calcium lime. The mixture from the first reactor is then aerated and passed to a second reactor. A sludge separates and some of this sludge is then recycled to the first reactor. About 20 pounds of solids in the sludge are required for each pound of solids precipitated from the acid water. The resulting water is suitable for plant use or can be discharged without pollution. OR 73-28

MD73-41 THE TRUE COST OF REVERSE OSMOSIS

Kremen, S. S. (Gulf Environ. Systems, San Diego, Calif.), Ind. Wastes 19 (6), 24-26 (1973). The use of reverse osmosis for abating acid mine drainage pollution has received much attention. The costs of the process and of its applications are discussed in detail. OR 73-44

MD73-42 STATE OF THE ART - ACID MINE DRAINAGE CONTROL

Lombardo, J. L., Amer. Mining Congr. Conv., Denver, Colo., Sept. 9-12, 1973. 12 pp.+ Acid mine drainage is classified into three categories. The mine drainage treatment processes at Consolidation Coal Company's Pittsburgh area mines, the Mingo, McMurray, and Whetstone plants, are described and flow charts for each of these plants are included. Cost comparisons are also shown. Consol mines coal in seven states and must meet the effluent standards which vary from one state to another. OR 73-22

MD73-43 CONSTRUCTING NON-POLLUTING COAL MINE WASTE DISPOSAL SYSTEMS

Lounsbury, R. E. (Monterey Coal Co.), Mining Eng. 25 (6), 48-51 (1973). The coal refuse slurry and coal washery water handling systems at Monterey Coal Co. No. 1 Mine in Macoupin County, Illinois are described. Clarified water is recycled from the slurry ponds into the coal preparation plant with make-up as needed from a fresh water reservoir and drainage finally to Spanish Needle Creek. Construction of refuse piles to meet Illinois and U.S. EPA water pollution control requirements is discussed. OR 73-79

MD73-44 AN APPRAISAL OF NEUTRALIZATION PROCESSES TO TREAT COAL MINE DRAINAGE

Lovell, H. L., Pa. State Univ., Rept. to Pa. Dept. Environ. Resour. and U.S. EPA, Environ. Protection Technol. Ser. EPA-670/2-73-093 (Nov. 1973). 347 pp. NTIS, PB-231 249/AS. The results of neutralization studies of four different mine waters at the Hollywood, Pennsylvania mine drainage treatment plant are reported. Eight different neutralizing reagents were used. In addition, water handling, sludge, and biochemical oxidation of ferrous iron received attention. Costs of using the different reagents are also compared. OR 73-39

MD73-45 COAL MINE DRAINAGE POLLUTION - 1973

Lovell, H. L., Pa. State Univ., Earth and Miner. Sciences 42 (7), 54-55 (April 1973). This general article provides a quick guide to the successive steps taken, and the progress made, through legislation, research, and action programs toward cleaning up streams polluted by mine drainage. OR 73-19

MD73-46 PRELIMINARY REPORT ON THE WATER QUALITY OF THE SOUTH FORK OF THE LITTLE CONEMAUGH RIVER DURING 1972

Mackey, H. E., Jr. (Univ. of Pittsburgh at Johnstown), February 1973. 23 pp. A detailed water quality survey of the watershed of the South Fork of the Little Conemaugh River in southeastern Cambria County, Pennsylvania, indicates that there are seven significant sources of acid mine drainage input, one of which is the largest source within the entire Kiskiminetas River Basin. Typical pH, sulfate, and total iron values are given. Sewage contamination from storm and sewage drains and individual homes of Beaverdale, Allendale, Dunlo, Sidman, and St. Michael is also described. (Author's abstract) OR 73-1

MD73-47 PREVENTING THE SEDIMENTATION OF STREAMS IN A PACIFIC NORTHWEST COAL SURFACE MINE

McCarthy, R. E. (Washington Irrigation & Development Co.), Natl. Coal Assoc./Bitum. Coal Res., Inc., First Res. Applied Technol. Symp. Mined-Land Reclamation Preprints, Pittsburgh, Pa. (1973). pp 277-286. Drainage from a surface mine near Centralia, Washington is discharged into Hanaford Creek. Because the claylike soil tended to remain in suspension, polyelectrolyte flocculant treatment and settling ponds were used to clarify the water. The process was designed to handle the extended periods of high runoff and occasional peak flows common to the area. It has also been automated to continually monitor the water flow and to add the correct amount of flocculant into the turbid water. Water analysis three times a day above and below the mine, assures that the overflow from the final settling pond does not carry siltation. Acid forming materials are not present. OR 73-85

MD73-48 SURFACE MINE SILTATION CONTROL

McCarthy, R. E., Am. Mining Congr., Coal Convention, Report on Coal Technology, Vol. II, 1973. 9 pp. In clarifying turbid water from the mining operation, suspended sediment is flocculated with a polyelectrolyte. The suspension settles out in ponds and clear water overflows into the receiving stream. OR 73-86

MD73-49 A CHEMICAL AND BIOLOGICAL EVALUATION OF THREE MINE DRAINAGE TREATMENT PLANTS

McPhilliamy, S. C. and Green, J., U.S. EPA, Region III, Wheeling Field Office, Surveillance Anal. Div., Work Document No. 47 (1973). 76 pp. Chemical and biological sampling was conducted at three mine drainage treatment plants operated by the Jones and Laughlin Steel Corp. and at an untreated mine discharge on Little Indian Creek north of Rivesville, West Virginia. Samples were taken of the effluents before and after treatment and in the receiving streams above and below the discharges monthly from May through August 1972. In addition to parameters generally associated with mine drainage, values were determined for manganese, aluminum, calcium, magnesium,

MD73-49 (continued)

cadmium, chromium, copper, lead, nickel and zinc. The treatment plants were generally effective, but, on occasion, two of the plants discharged excessive acidity and iron and this noticeably affected the benthos in the receiving streams. (Authors' abstract adapted) OR 73-60

MD73-50 METHODS FOR IDENTIFYING AND EVALUATING THE NATURE AND EXTENT OF NON-POINT SOURCES OF POLLUTANTS

U.S. EPA, Office Air Water Programs, EPA-430/9-73-014, 1973. 261 pp. Acid mine drainage and sediment from surface mining and underground mining for coal are one of the areas considered in this report. OR 73-56

MD73-51 MINE DRAINAGE POLLUTION WATERSHED SURVEY, THE NORTHERN YOUGHIOGHENY RIVER COMPLEX: CHERRY CREEK, CASSELMAN RIVER WATERSHEDS, GARRETT COUNTY, MARYLAND: VOL. I

Baker-Wibberley and Associates, Inc., Rept. to Md. Dept. Natural Resour., May 1973. 101 pp.+ The geology, hydrology, and climate of the area are presented in detail. The appendixes include results of analyses of water taken in the sampling program; amounts of stream-flow; aquatic biota sampling data; description of active mines and recommendation for abatement; and location and description of mines needing no abatement. As a result of the survey, twelve abatement projects, mainly on abandoned underground mines or on surface mined areas with drainage problems, are recommended with cost estimates. OR 73-76

MD73-52 MINE DRAINAGE POLLUTION WATERSHED SURVEY, THE NORTHERN YOUGHIOGHENY RIVER COMPLEX, CHERRY CREEK AND CASSELMAN RIVER WATERSHEDS, GARRETT COUNTY, MARYLAND: VOL. II

Skelly and Loy, Engineers, Consultants, Rept. to Md. Dept. Natural Resour., May 1973. 368 pp. This is Appendix A of "The Cherry Creek - Casselman River Improvement Plan" report from the Maryland Department of Natural Resources to the Appalachian Regional Commission. It gives the details of the abandoned mine drainage problem, inventories drainage sources, recommends abatement plans and priority pollution abatement projects, and estimates abatement costs. The report also contains a short paper on limestone use for surface mine reclamation and a comprehensive bibliography. OR 73-68

MD73-53 UTILIZATION OF NEUTRALIZED ACID MINE DRAINAGE LIQUOR IN HIGHWAY CONSTRUCTION

Minnick, L. J., Webster, W. C., and Hilton, R. G., G. & W. H. Corson, Inc., Final Rept. to U.S. EPA, Office Res. Monitoring, Contract DOT-FH-11-7879, Dec. 1973. 22 pp. Neutralized acid mine drainage sulfate sludge was used with other waste materials to produce road base and synthetic aggregate compositions. Field and laboratory demonstrations showed that necessary strengths and mechanical properties were obtained. Other waste materials used were brine sludge, bottom ash, fly ash, and crushed battery cases. The test data are tabulated. OR 73-78

MD73-54 EFFECTS OF ACID MINE DRAINAGE ON THE STREAM ECOSYSTEM OF THE EAST FORK OF THE OBEY RIVER, TENNESSEE

Nichols, L. E., Jr. and Bulow, F. J. (Tenn. Technol. Univ.), J. Tenn. Acad. Sci. 48 (1), 30-39 (1973). In this 1970 study, a survey of water quality, macroinvertebrates, fish, and aquatic flora showed effects of acid mine drainage. At the sampling station just above the confluence with the West Fork and the entrance into the reservoir they feed, the East Fork was found to be recovering from acid mine drainage effects. The alkaline West Fork was also considered to have a buffering effect on the East Fork. OR 73-35

MD73-55 ORSANCO YEARBOOK 1973

Ohio River Valley Water Sanitation Commission, Twenty-fifth Annual Rept., Cincinnati, Ohio, 1973. 16 pp. This brief report of the ORSANCO activities for the year 1973 contains short articles on water quality, monitoring and work in progress. A large map outlines the area of the activities and a financial report is included. OR 73-57

MD73-56 GEOLOGIC EVALUATION OF PROBABLE RESULTS OF MINING OF UPPER FREEPORT COAL NEAR MAPLE RUN MONONGALIA COUNTY WEST VIRGINIA

Overbey, W. K., Jr. (W. Va. Univ.), Prepared for Cheat Lake Area Environmental Conservancy, Morgantown, W. Va., April 10, 1973. 17 pp.+ The survey indicates that the area is extremely faulted and is unfavorable for deep mining. The formation of acid mine drainage is also predicted. OR 73-37

MD73-57 LABORATORY STUDY OF SELF-SEALING LIMESTONE PLUGS FOR MINE OPENINGS

Penrose, R. G., Jr. and Holubec, I., Cyrus Wm. Rice Div. - NUS Corp., and E. D'Appolonia Consulting Engineers, Inc., Rept. to EPA, Environ. Protection Technol. Ser. EPA-670/2-73-081 (Sept. 1973). 217 pp. NTIS, PB-228 586/AS. Pilot plant operations utilized limestones selected from results of a previous neutralization study; synthetic mine waters prepared to EPA formulations for ferric, ferrous, and ferric/ferrous solutions; and mixtures of bentonite, fly ash and air-cooled blast furnace slag additives with the aggregate to form the plugs. Experimental results indicated that permeability, compressibility and strength of a limestone plug are primarily a function of the particle size distribution and density. Plug performance was most effective with high limestone placement density and smaller gradation of stone. Ferric waters were controlled mout effectively. Additive effects were less significant throughout the tests. (From authors' abstract) OR 73-48

MD73-58 PREPARATION OF PLANS AND SPECIFICATIONS FOR POLLUTION ABATEMENT ACTIVITIES IN CHERRY CREEK WATERSHED, MARYLAND

Skelly and Loy, Engineers-Consultants, and Zollman Associates, Rept. to Appalachian Regional Comm., ARC Contract #73-35/RPC 767, 1973. (109 pp.+) Detailed plans and cost estimates are given for specific projects to abate drainage from six surface and two deep mines in the watershed. This is a part of the project reported in 73-68 and 74-20. OR 73-90

MD73-59 PROBLEMS CAUSED BY COAL MINING NEAR FEDERAL RESERVOIR PROJECTS

Rept. by the Comptroller General of the United States, to the Conservation and Natural Resources Subcomm., Comm. Govern. Operations, U.S. House Representatives, B-177092 (Oct. 2, 1973). 53 pp. Eight water resources projects of the Corps of Engineers in Kentucky and West Virginia were reviewed to determine effects on the projects of coal mining. Major problems included sedimentation, acid mine drainage, improperly constructed and maintained access roads, careless dumping of coal refuse, and hillside scars. The recommendations emphasize the government regulations which should be enforced and legislation which is needed. OR 73-67

MD73-60 PROCESSES, PROCEDURES, AND METHODS TO CONTROL POLLUTION FROM MINING ACTIVITIES

Skelly and Loy Rept. to U.S. EPA, Washington, D.C., EPA-430/9-73-011, Oct. 1973. 390 pp. Methods for controlling and abating water pollution from both deep and surface mining are described. OR 73-29

MD73-61 RECLAMATION: RESTORING BEAUTY AND BALANCE IN US STEEL'S GOAL

Coal Age 78 (11), 100-104 (1973). Broadcasting, hydroseeding, aerial seeding, and seedling planting have been used to revegetate 17,000 reclaimed acres in Kentucky,

MD73-61 (continued)

West Virginia, Pennsylvania, and Alabama. Lime neutralization is used to treat mine drainage where needed. Although a lime storage tank has been built before the aerator at the Maple Creek water treatment plant, the water presently is alkaline so that only aeration and settling are required. The water from the Robena complex ranges from mildly alkaline to highly acid, and the treatment includes neutralization plus aeration and settling. OR 73-20

MD73-62 RELATIVE ACID-PRODUCING POTENTIAL OF COAL

Renton, J. J. (1), Hidalgo, R. V. (1), and Streib, D. L. (2) [(1) W. Va. Geol. Surv. and (2) Ohio Geol. Surv.], W. Va. Geol. and Econ. Surv., Morgantown, W. Va., Environ. Geol. Bull. No. 11, (Aug. 1973). 7 pp. A modified Soxhlet extraction of specially prepared samples of a series of 40 coals representing 19 different coal seams was carried out to determine the acid producing potential of the coals upon weathering. Pittsburgh, Upper Freeport, and, to a lesser extent, Bakerstown coal were determined to be the major acid producers with the data for the Pittsburgh seam showing less variation than data for Upper Freeport coal. The report also includes results of a study to find a good field indicator of acidity and suggests the conductivity/sulfate ratio. OR 73-18

MD73-63 ACID MINE DRAINAGE QUANTITY AND QUALITY GENERATION MODEL

Ricca, V. T. and Chow, K. (Ohio State Univ., Columbus, Ohio), AIME 102nd Ann. Meet., Chicago, Ill., 1973. 38 pp. The authors present a computer model which predicts average daily mine water discharge, acid loading, and average daily flow in receiving streams. They show its application to the McDaniels mine in southeastern Ohio. OR 73-31

MD73-64 BASE DATA AND RECLAMATION COST DEVELOPMENT FOR THE INITIATION OF A COMPREHENSIVE LONG RANGE RECLAMATION PLAN

Robins, J. D., Skelly and Loy, Engineers-Consultants, Tech. Rept. to Bd. on Unreclaimed Strip Mined Lands, Ohio Dept. Natural Resour., Proj. No. 73-D6, 1973. 181 pp.+ Both published information and field studies were used to compile an inventory of surface mined lands and sources of acid mine drainage in the eastern Ohio coal field. The area was divided into 79 watersheds for ease in handling data. Based on the results of the survey the watersheds were combined into priority groupings. Fifteen watersheds were identified as being major acid producing areas in which extensive reclamation was recommended as soon as funding becomes available. OR 73-89

MD73-65 GAS REQUIREMENTS TO PRESSURIZE ABANDONED DEEP MINES

Robins, J. D., Cyrus Wm. Rice Div. - NUS Corp., Rept. to Pa. Dept. Environ. Resour. and U.S. EPA, Environ. Protection Technol. Ser. EPA-670/2-73-054 (Aug. 1973). 192 pp. NTIS, PB-224 831. The work was done to determine gas injection rates needed to develop and maintain slight pressures in a mine over ambient conditions during changes in the barometric pressure. The purpose was to determine the feasibility of blanketing an abandoned deep mine with an inert gas in order to eliminate pyrite oxidation and resulting acid mine drainage. Tests at the larger (50 acres) test mine were inconclusive, but the final tests at the smaller (15 acres) mine were encouraging. General observations indicated that this method of acid mine drainage abatement is not economically feasible where there are certain conditions which could result in many unidentifiable air passage ways to the surface. (Author's abstract adapted) OR 73-24

MD73-66 SEALING OF COAL REFUSE PILES

Scott, R. B. (Natl. Environ. Res. Center, Crown, W. Va.), U.S. EPA, Natl. Environ. Res. Center, Office of R&D, Cincinnati, Ohio, Program Element 1B2040, July 1973.

MD73-66 (continued)

15 pp. Several methods of sealing refuse piles developed under EPA sponsorship were evaluated in field trials carried out for almost a year. Seven 14' x 14' x 12" deep containers were constructed for the coal refuse so that water percolating through the pile could be measured. Plastic covering, carbonate bonding, clay-type soil, sodium silicate, sodium silicate and sodium aluminate were tested. Leachates were tested for conductance, pH, acidity, alkalinity, calcium, magnesium, aluminum, sulfate, and total iron. The results show that the plastic cover was the most successful sealant although it required constant attention to keep it in place. Sodium silicate was the second most successful treatment but seemed to be losing its effectiveness at the end of the test period. Carbonate bonded layers at first were successful but broke up under weathering. OR 73-17

MD73-67 WATER REUSE IN INDUSTRY: PART 3 - MINE WATER

Shackelford, J. M., Mech. Eng. 95 (6), 32-34 (1973). The problem of acid mine drainage is outlined and a number of treatment methods developed with EPA support are described. OR 73-11

MD73-68 WATER STORED IN ABANDONED MINES AS A MINERAL RESOURCE

Shotts, R. Q. (Univ. Alabama, Dept. Civil Miner. Eng.), AIME Ann. Meet., Chicago, Ill., Feb. 25 - March 1, 1973. Preprint No. 73AG5. 11 pp. The use of abandoned mines in the Cahaba coal fields of Alabama as water reservoirs is advocated. Estimates of water in several coalbed areas is 7.6 billion gallons. Since drainage from abandoned mines may need treatment, it is suggested that the treated water be used for industrial purposes where feasible. OR 73-53

MD73-69 THE STATUS OF ACTIVE DEEP MINES IN THE MONONGAHELA RIVER BASIN

U.S. EPA, Region III, Wheeling Field Office, Surveillance Anal. Div., Work Document No. 46 (1973). 129 pp. As a result of the Monongahela Enforcement Conference in 1971, the survey of mines in the area, carried out after the first conference in 1963, was updated. Each of the active underground mine sites previously listed was revisited to determine current operational status and to sample any mine drainage discharges. Although new mine sites were not actively sought, any that were encountered in the course of the survey were added to the inventory. The detailed results of the inventory are presented including results from water analyses for pH, acidity, iron, sulfate, and amount of flow. OR 73-10

MD73-70 ABATEMENT OF MINE DRAINAGE POLLUTION BY UNDERGROUND PRECIPITATION

Stoddard, C. K., Parsons-Jurden Div., The Ralph M. Parsons Co., Rept. to EPA, Environ. Protection Technol. Ser. EPA-670/2-73-092 (Oct. 1973). 125 pp. NTIS, PB-229 407/AS. Field tests to confirm laboratory tests showing sealing effect of sludge from lime or limestone neutralization were conducted in an abandoned coal mine. The results of pumping hydrated lime and limestone slurries behind rubble barriers in the mine indicates that only temporary sealing of the outflow was achieved, and that neutralization took place when the interior water flow conditions were favorable. Placement of the injection outlets, dispersion of the lime slurry, volume of water flowing, and direction of flow in the mine relative to other outlets greatly affect the efficiency of sealing and neutralization of the mine drainage effluent. (From author's abstract) OR 73-51

MD73-71 SURFACE MINING DISTURBANCE AND WATER QUALITY IN EASTERN KENTUCKY

Striffler, W. D. (Northeastern Forest Expt. Sta., USDA), in "Ecology and Reclamation of Devastated Land," Vol. 1, R. J. Hutnik and G. Davis, Eds., New York: Gordon and Breach, 1973. Paper II-4. pp 175-191. A survey of water quality was conducted in eastern Kentucky during the summer of 1966. A total of 180 sampling points, including all fourth-order and larger watersheds, were measured. Field measurements

MD73-71 (continued)

included stream discharge, water temperature, dissolved oxygen, pH, oxidation-reduction potential and specific conductance. Laboratory determinations included Al, Ca, Mg, total Fe, Mn, and sulfates. In summary, although acid pollution is a very serious problem on small, severely disturbed watersheds, it is not important on the larger watersheds or major rivers during low-flow conditions in eastern Kentucky. (From author's abstract) OR 73-87

MD73-72 FACTORS CONTROLLING SLUDGE DENSITY DURING ACID MINE DRAINAGE NEUTRALIZATION

Svanks, K. and Shumate, K. S., Ohio State Univ., Water Resour. Center, Proj. Completion Rept. No. 392X, to U.S. Dept. Int., Office Water Resour. Res., 1973. 156 pp. This laboratory project was done to develop procedures for obtaining denser settled sludges from synthetic acid mine drainage by lime precipitation. Results showed that precipitation of iron from acid mine drainage in the form of high density magnetite is possible, but the problem of slow conversion of green rust II to magnetite at temperatures below 25°C together with severe interference of aluminum to the formation of magnetite makes the application in the field unlikely. Related literature is discussed and extensive sections cover formation of magnetic sludges and their neutralizations. A list of 93 references is given. (Adapted from Introduction) OR 73-55

MD73-73 CASE HISTORY ON ACID MINE DRAINAGE CONTROL

Temmel, F. M., Amer. Mining Congr. Conv., Denver, Colo., Sept. 9-12, 1973. 18 pp.+ The high density sludge process developed by Bethlehem Steel Company for treating acid mine drainage is now in use at the major mine water discharges at the Cambria Division. Settled sludges contain at least 40% solids. This process differs from the conventional lime neutralization in that it recycles a controlled volume of the settled sludge and mixes this sludge with lime slurry in a reaction tank prior to neutralization and separation steps. The pictures show the plant units and charts give the performance data. The process is also used by Bethlehem to treat waste acid from their pickling operations. OR 73-23

MD73-74 STRIP-MINED WATERSHED HYDROLOGIC DATA ACQUISITION STUDY

Tschantz, B. A., Water Resour. Res. Cent., Univ. Tenn., Res. Rept. No. 35 (Aug. 27, 1973). 17 pp. NTIS, PB-223 558. This was an aerial photographic study made using infrared methods to define two small East Tennessee watersheds. The information is to be used for hydrologic and land-use purposes. Three flights were made covering 5,041 acres of watershed representing 847 acres of disturbed bench, slope and slide areas. A list of 15 figures shows the mapped areas and several pictures give the overall view of the watershed area. Low level altitude infrared photography is useful for mapping and measuring surface-mine disturbed areas. OR 73-88

MD73-75 DISSOLVED ALUMINUM IN ACID SULFATE SPOILS AND IN ACID MINE WATERS

van Breemen, N., Soil Sci. Soc. Amer. Proc. 37, 694-697 (1973). Analytical data on water samples from acid sulfate soils and acid mine spoils indicate that the upper limit of dissolved Al is regulated by a basic aluminum sulfate with the stoichiometric composition $AlOHSO_4$. The observed solubility relationship, $pAl + pOH + pSO_4 = 17.23$, can be useful in defining environmental conditions in terms of pH and dissolved sulfate for the occurrence of Al concentrations toxic to plants. (Author's abstract) OR 73-41

MD73-76 FIGHTING POLLUTION WITH A POLLUTANT

Van der Horst, J. M. A. (Surface Research, Inc.), Effluent Water Treat. J. 13 (7), 495, 497 (1973). This article advocates mixing typical sewage containing phosphates with acid mine drainage to precipitate iron and other heavy metal phosphates,

MD73-76 (continued)

thus reducing both phosphate and metals in the polluted effluents. The populous upper Ohio Valley is seen as an area with both the acid mine drainage and sewage available to utilize this idea. OR 73-59

MD73-77 EFFECT OF STRIP MINING ON WATER QUALITY

Vimmerstedt, J. P., Finney, J. H., and Sutton, P., Ohio Agr. Res. Develop. Cent., Wooster, Ohio, Rept. to Ohio State Univ., Water Resour. Cent., Columbus, Ohio, Jan. 1973. 54 pp. NTIS, PB-217 872. This report covers two separate topics. In the study of the effect of surface-mining on water quality of Little Mill Creek, Ohio, four sampling points were selected and used over a 236-week period. Results showed that manganese concentrations near the mining area exceeded standards 80% of the time while this same chemical in a creek not affected by mining exceeded standards only 13% of the time. Sulfate, magnesium, calcium, iron, aluminum and hydrogen ion concentration were also monitored and found to have higher values in stream flow affected by surface mining. Objective of the second phase was to measure infiltration rates on spoil banks and to correlate variations with spoil characteristics. Analysis of several variables did not account for variation in the infiltration. OR 73-49

MD73-78 ACID COAL MINE DRAINAGE EFFECTS ON AQUATIC LIFE

Warner, R. W. (EPA, Denver, Colo.), in "Ecology and Reclamation of Devastated Land," Vol. 1, R. J. Hutnik and G. Davis, Ed., New York: Gordon and Breach, 1973. pp 227-237. The finding that "pH may provide a reliable index to damages to the biota of streams polluted by acidic coal mine drainage," is based on a survey of several streams in Pennsylvania and West Virginia. OR 73-43

MD73-79 WATER QUALITY MANAGEMENT ELEMENT FOR THE KENTUCKY RIVER AREA DEVELOPMENT DISTRICT COMPREHENSIVE WATER AND SEWER PLAN

Mayes, Sudderth & Etheredge, Inc., Lexington, Ky., Rept. to Kentucky River Area Development District, June 1973. 77 pp. The Kentucky River is polluted from three main sources: coal mining activities, untreated domestic waste, and municipal plant effluent. The report includes population trends, water and sewer plans, water quality considerations, and implementation of water and sewer plans. Extensive water quality and point source pollution data are charted and tabulated, and maps give the stream locations and their pollution circumstances. An outline of water quality standards is given for the state of Kentucky. OR 73-36

MD73-80 APPLICATIONS OF REVERSE OSMOSIS TO ACID MINE DRAINAGE TREATMENT

Wilmoth, R. C. (Crown Mine Drainage Control Field Site), U.S. EPA, Environ. Protection Technol. Ser. EPA-670/2-73-100 (Dec. 1973). 159 pp. Spiral-wound reverse osmosis systems were tested on four different acid mine drainage discharges in West Virginia and Pennsylvania. At all sites, the limiting factor in high recovery operation was calcium sulfate insolubility. Application of reverse osmosis was demonstrated to be technically feasible for a large percentage of acid mine drainage discharges. A process called "neutrolosis" was developed in which the reverse osmosis brine is neutralized and clarified, and the supernatant recycled to the influent to the reverse osmosis unit. Neutrolosis recoveries as high as 98.8 percent were achieved at a ferric iron acid discharge site. (From author's abstract) OR 73-52

MD73-81 MINE DRAINAGE POLLUTION CONTROL VIA REVERSE OSMOSIS

Wilmoth, R. C. and Hill, R. D., Min. Eng. 25 (3), 45-47 (1973). The application of reverse osmosis in the neutrolosis process is described. OR 73-47

MD73-82 SIMULATION AND OPTIMIZATION OF ACID MINE DRAINAGE ABATEMENT ALTERNATIVES

Young, G. K., Taylor, R. S., and Selekof, J. S., Water Resources Engineers, Inc., Springfield, Va., Rept. to U.S. Army Corps of Engineers, Baltimore, Md., Jan. 1973. 70 pp.+ NTIS, AD-757 782. This study of the Tioga River Basin in Pennsylvania evaluates a computer model which simulates three abatement methods: mine sealing, surface water diversion, and lime treatment. Summary conclusions indicate control costs of $400,000/yr and that lime neutralization is favored over diversion ditches in abatement alternatives. OR 73-32

MD73-83 WATER INFILTRATION CONTROL TO ACHIEVE MINE WATER POLLUTION CONTROL - A FEASIBILITY STUDY

Zaval, F. J. and Robins, J. D., Cyrus Wm. Rice Div. - NUS Corp., Rept. to W. Va. Dept. Natural Resour. and U.S. EPA, Environ. Protection Technol. Ser. EPA-R2-73-142 (Jan. 1973). 185 pp. NTIS, PB-217 886. The Dents Run Watershed, Monongalia County, West Virginia, the site selected for the study, contains strip mines, drift mines, auger mines, refuse dumps, soil banks, and discharge boreholes, all discharging acid mine water. Project feasibility is based upon the performance and results of investigative measures which included: investigation of each mined area and abandoned drift openings, which resulted in a detailed description of each site; sampling and analysis of all receiving streams and discharge pits to determine the severity of acid mine water pollution; and evaluation and selection of weir structures, monitor enclosures and instruments to be placed in unattended areas to provide a continuous record of stream conditions. Recommendations are made for reclamation and treatment at each site; and pertinent cost estimates are developed for the construction, installation and operation of monitoring facilities as well as the reclamation work. (From authors' abstract) OR 73-4

1974

MD74-1 ACID MINE DRAINAGE FIT TO DRINK

Rohm and Haas Reporter, Winter, 1974-1975. pp 19-21. The Rohm and Haas plant at Hawk Run near Philipsburg, Pennsylvania has demonstrated that a modification of the Desal ion exchange process to treat acid mine water can produce water for the public supply. OR 74-67

MD74-2 COAL MINING AND ITS EFFECT ON WATER QUALITY

Ahmad, M. U. (Ohio Univ.), in "Extraction of Minerals and Energy: Today's Dilemmas," R. A. Deju, Ed., Ann Arbor: Ann Arbor Science Publishers, Inc., 1974. pp 49-56. The effect on water quality of both surface and underground mining is discussed. The hydrology of the Sheban Mine, Mahoning County, Ohio is used as an example of a typical surface mine. OR 74-5

MD74-3 COAL MINING AND ITS EFFECT ON WATER QUALITY

Ahmad, M. U. (Ohio Univ.), Water Resour. Problems Related to Mining, Am. Water Resour. Assoc., Proc. No. 18, June 1974. pp 138-148. The author discusses mine water and drainage problems of coal mining including the mechanics of acid production, and hydrological studies of deep and surface mines. Constituents found in Illinois coals are tabulated. OR 74-90

MD74-4 WEATHERING OF CLAY MINERALS BY SIMULATED ACID COAL SPOILBANK SOLUTIONS .

Barnhisel, R. I. and Rotromel, A. L. (Univ. Ky.), Soil Sci. 118 (1), 22-27 (1974). Kaolinite and mica clay minerals were agitated with various concentrations of sulfuric acid for periods of up to six months to simulate leaching by coal-related acid drainage. Aluminum, iron, potassium, and silicon were released into the solution phase. X-ray diffraction studies indicated that kaolinite and mica clays would weather at the same rate. OR 74-60

MD74-5 SOIL AS A MEDIUM FOR THE RENOVATION OF ACID MINE DRAINAGE WATER

Beers, W. F. (2), Ciolkosz, E. J. (1), and Kardos, L. T. (1) [(1) Pa. State Univ., Dept. Agronomy and (2) Roy F. Weston, Inc.], Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 160-171. Also published as Pa. State Univ., Inst. Res. Land Water Resour., Reprint Ser. No. 37. Two soil samples were used as treating agents for acid mine drainage in an experimental laboratory project. The soils were placed in columns 40 inches high and 5 inches of acid mine water were added each week for a period of 42 weeks. Effluent samples were analyzed weekly for potassium, calcium, magnesium, manganese, copper, aluminum and sodium. The behavior of each soil with respect to each element is discussed and the analytical data from the effluent samples are shown in graphs. Both initially and throughout the study period the soils showed substantial but different ability to renovate acid mine water. This ability is dependent on the soils' physical and chemical characteristics, particularly their $CaCO_3$ content.
OR 74-38

MD74-6 ECOLOGY OF IRON-OXIDIZING BACTERIA IN PYRITIC MATERIALS ASSOCIATED WITH COAL

Belly, R. T. and Brock, T. D. (Univ. Wis., Dept. Bacteriology), J. Bacteriol. 117 (2), 726-732 (1974). This work describes a method for measuring $^{14}CO_2$ uptake by chemolithotrophic bacteria directly in pyritic materials associated with coal and coal refuse. Maximal $^{14}CO_2$ uptake occurred in coal refuse material 2-3 years old, and only slight incorporation was demonstrated in fresh material or material 40 years old. Surface samples demonstrated maximal $^{14}CO_2$ uptake as compared to samples below 8-10 cm with only slight activity. Optimum uptake activity occurred at 20-30°C, and a moisture content of 23-35%. Heterotrophic fungi and yeasts were routinely isolated in high numbers from acidic coal refuse. There was good correlation between $^{14}CO_2$ uptake and the most probable number of iron-oxidizing bacteria. (From authors' abstract) OR 74-4

MD74-7 FACTORS AFFECTING THE SELECTION OF MINE DRAINAGE TREATMENT METHODS

Bhatt, H. G. (Michael Baker, Jr., Inc.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 331-356. This paper reviews the various methods available for treatment of acid mine drainage and in many cases gives cost estimates. The main emphasis is on neutralization, with differentiation between treating high ferric and high ferrous iron drainage. Neutralization is also considered in combination with electrochemical, biochemical, and ozone oxidation. Several different neutralizing agents are discussed. The most commonly used are lime and limestone and their advantages and disadvantages are pointed out. Lime is used in full-sized treatment plants, several of which are described. The only plant identified as using limestone was treating a drainage of about 150 gallons per minute having moderate levels of iron, mostly ferric. Limestone has been used in a number of experimental processes which are also described.
OR 74-49

MD74-8 PILOT PLANT STUDIES: PURIFICATION OF ACID MINE DRAINAGE BY NEUTROLOSIS PHASE I

Blackshaw, G. L., Pappano, A. W., and Arakali, V. S. (Dept. Chem. Eng.), W. Va. Univ., Rept. to U.S. EPA, National Environ. Res. Cent., Cincinnati, Ohio, Proj. No. 14010 HED, undated. 30 pp. This report outlines the pilot scale work done on a continuous reverse osmosis unit designed to handle 60,000 gal/day of acid mine drainage. The continuous run was set for 240 hours to demonstrate the operating capability. The plant operated satisfactorily purifying ferrous iron acid mine waters at 50% recovery. A detailed description of the plant and its operation is included. The work reported was completed as of May 1973. OR 74-12

MD74-9 PILOT PLANT TREATMENT OF AMD BY REVERSE OSMOSIS BASED TECHNIQUES

Blackshaw, G. L., Pappano, A. W., and Arakali, V. S. (W. Va. Univ., Dept. Chem. Eng.), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 312-330. The design, construction, and initial operation of the reverse osmosis treatment facility at Crown, West Virginia are described. The plant is capable of producing 60,000 gallons per day of nearly potable water from predominately ferrous mine drainage. OR 74-48

MD74-10 THE IMPROVED DENSIFICATION OF SLUDGE FROM NEUTRALIZED ACID MINE DRAINAGE

Bosman, D. J., J. S. Afr. Inst. Mining Met. 74 (9), 340-348 (1974). This paper describes an acid water treatment devised to neutralize acid mine drainage from the workings of Coronation Collieries, Kromdraai, South Africa. Since limestone was not readily available, the company decided to use the Bethlehem Steel Company approach of adding a lime slurry plus recirculated sludge to the main drainage flow. This gave a sludge density of 22 percent when gradual mixing techniques were used. Diagrams of the pilot treatment plant are shown and data are tabulated. The treated mine drainage flows into Loskop Dam from which water is used almost exclusively for irrigation. OR 74-19

MD74-11 COAL AND COAL MINE DRAINAGE

Boyer, J. F. and Gleason, V. E. (Bituminous Coal Res., Inc.), J. Water Pollut. Contr. Fed. 46 (6), 1290-1294 (1974). There are forty references in this review of the literature of 1973. Topics covered include river basin studies in coal producing areas of the East; effects of mine drainage on ecosystems; costs of abatement; means to prevent acid mine drainage formation; and studies on mine drainage sludges. OR 74-16

MD74-12 PALEOENVIRONMENT - PREDICTOR OF ACID MINE DRAINAGE PROBLEMS

Caruccio, F. T. and Ferm, J. C. (Univ. S.C., Dept. Geol.), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 5-10. The extensive research program that is attempting to predict the occurrence and mode of distribution of sulfur in coal by identifying the environment of deposition of that stratum is summarized. Factors identified as generating acid mine drainage are shown in the preliminary study to be related and incorporated into a sedimentary model based on present day analogues that categorize the environments into back barrier, lower delta plain, upper delta plain and alluvial sequences. (Authors' Summary and Conclusions Modified) OR 74-28

MD74-13 THE CHERRY CREEK-CASSELMAN RIVER ENVIRONMENTAL IMPROVEMENT PLAN

Md. Dept. Natural Resour., Rept. to Appalachian Regional Comm., Jan. 1974. 62 pp. This comprehensive study of the watershed area in Maryland describes existing problems including mine drainage, municipal and industrial discharges, air pollution sources, and solid waste disposal. Specific reclamation projects are recommended for mine drainage abatement. Individual sources are identified, acid production and abatement costs are listed, and an inventory of municipal and industrial discharges is also included. OR 74-20

MD74-14 THE USE OF A FLUIDIZED BED ELECTRODE FOR THE REMOVAL OF DISSOLVED IRON FROM ACID MINE DRAINAGE

Crane, M., Ph.D. Thesis, N.Y. Univ., School Eng. and Sci., 1974. 73 pp. University Microfilms, 74-21,543. A one-inch diameter bed of copper particles was used successfully to remove ferrous and ferric ions from synthetic acid mine drainage at flow rates of .211 to .411 cc/sec. In a single pass through the bed, up to 67 percent of the ferrous ion was removed. OR 74-84

MD74-15 SEDIMENT YIELD FROM STRIP-MINED WATERSHEDS IN EASTERN KENTUCKY

Curtis, W. R. (Northeastern Forest Expt. Sta., USDA), Natl. Coal Assoc./Bitum. Coal Res., Inc., Second Res. Applied Technol. Symp. Mined-Land Reclamation Preprints, Louisville, Ky. (1974). pp 88-100. Erosion rates and sediment yields from surface mined areas in eastern Kentucky watersheds were determined by studies of three settling basins built on mined and unmined areas in Breathitt County. Data on sedimentation, watershed size, disturbed acreages, dates of mining, and precipitation were used to develop sediment basin specifications and requirements. Results showed highest sediment yield during the first six months after mining. Erosion rates decreased to fairly low levels within three years. Revegetation is given as the most effective sediment-control measure when done in minimum time following mining. Also, an area mined using a number of "head of the hollow" fills and ridge top removal showed reduced sediment yield. OR 74-85

MD74-16 DESIGN OF SURFACE MINING SYSTEMS IN EASTERN KENTUCKY: VOLUME I - SUMMARY

Mathematica, Inc. and Ford, Bacon & Davis, Inc., Engineers, Rept. to Ky. Dept. Natural Resour. Environ. Protection and Appalachian Regional Comm., ARC-71-66-T1 (Jan. 1974). 98 pp.+ The viewpoints of environmentalist coalitions, the regulatory agency, and the surface mining industry are summarized to provide perspective on the kinds of issues that motivated this study. Also included is a detailed summary of the relevant characteristics of surface mining and regulation in 1971-72, including industry characteristics, economics, and mining practices; regulatory procedures and results; and environmental impacts. Progress to date in mining, regulation, and reduction of environmental impact is summarized, and areas where further progress is needed are identified. Recommendations for modernizing and improving existing regulatory and mining practices are made. (Authors' abstract adapted) OR 74-9

MD74-17 LIMESTONE FOR CONTROLLING ACID MINE DRAINAGE AND FOR TREATMENT OF ACID MINE WATER

Deul, M. (U.S. Bur. Mines), Tenth Forum Ind. Miner. Proc., Columbus, O., by Ohio Geol. Surv., 1974. pp 43-46. Limestone can be used effectively in treating acid mine water. Aside from a lower cost than for other treatment agents, limestone has the advantages of easy storage and effectiveness even when impure and in slack sizes. Limestone incorporated into waste piles in layers or as riprap can inhibit acid formation; limestone rubble packed in a mine entry offers promise in formation of a low-cost autogenous resilient seal. (Author's abstract) OR 74-79

MD74-18 DEVELOPMENT OF AN OVERALL ECONOMIC/ENVIRONMENTAL PLAN FOR THE MONONGAHELA RIVER BASIN

Gibbs and Hill, Inc., Rept. to Appalachian Regional Comm., Sept. 1974. Coal mining related problems including acid mine drainage, mine refuse piles, and unreclaimed surface mines are emphasized in this detailed survey of water and air pollution and land use problems of the Monongahela River Basin. This information is correlated with social and economic factors in developing priorities for environmental improvement of the three state, 18 county area. OR 74-53

MD74-19 MACROINVERTEBRATE COMMUNITY STRUCTURE AS AN INDICATOR OF ACID MINE POLLUTION

Dills, G. (1) and Rogers, D. T., Jr. (2) [(1) Haywood Tech. Inst., Clyde, N. C. (2) Univ. Ala., Birmingham], Environ. Pollut. 6 (4), 239-262 (1974). Water quality parameters and biological surveys at 10 sampling stations in Cane Creek, Alabama, showed that diversity of species was strongly affected by pH and was lowest in the most acid areas. Species diversity showed seasonal variation at unpolluted stations but not in polluted areas. OR 74-82

MD74-20 ENGINEERING AND ADMINISTRATIVE PROBLEMS--DEER PARK DAY-LIGHTING DEMONSTRATION PROJECT

Dougherty, M. T. (1), Moomau, H. F. (2), and Matis, J. R. (3) [(1) Ackenheil & Assoc. Geo Systems, Inc., (2) Potomac Eng. & Surveying, and (3) Md. Dept. Natur. Resour.], Natl. Coal Assoc./Bitum. Coal Res., Inc., Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 70-87. This paper describes the feasibility study of a project to reduce formation of mine drainage from a 70 acre site in Lostland Run Watershed of the Upper Potomac Basin near Deer Park in Garrett County, Maryland. The abatement method to be used, termed daylighting, includes removing the overburden, the entire remaining coal, and regrading the land. A 300-foot core sample at the project site showed a 50-inch seam of coal to be removed, 48 to 52 feet below the surface at the boring site. The overburden was evaluated and found to be favorable for vegetation with careful placement. Coal quality evaluation showed that as a whole the coal was high in sulfur and ash but that the 30 inch bottom section was a good grade. A water sampling program showed that the pollution load in the watershed area would be reduced by an estimated 500 lbs/day acid with elimination of mine drainage from the project site. OR 74-32

MD74-21 STREAM WATER CHEMISTRY OF MODEL RECLAMATION OF STRIP-MINED LAND

Elzam, O. E. (Case-Western Reserve Univ.), in "Extraction of Minerals and Energy: Today's Dilemmas," R. A. Deju, Ed., Ann Arbor: Ann Arbor Science Publishers, Inc., 1974. pp 211-230. In a reclamation project at an experimental surface mine site of 60 acres in Ohio, three hills of about 20 acres each were formed. Topsoil removed prior to mining was spread evenly over one hill. Two hills were terraced, one with and one without topsoil. All three hills were seeded. The water sampling program was set up so that the effect of reclamation on water quality could be evaluated and compared to water quality from undisturbed as well as partially reclaimed land. The results of the study showed that a combination of burying acid producing materials, land terracing, and topsoil application resulted in fast revegetation, reduction of erosion, and improvement in water quality. OR 74-7

MD74-22 SELECTION OF LIMESTONES AS NEUTRALIZING AGENTS FOR COAL MINE WATER

Ford, C. T. (Bitum. Coal Res., Inc.), Presented 10th Forum Geology Ind. Miner., Columbus, Ohio, April 18, 1974. 37 pp. Criteria for selecting limestones for acid mine drainage treatment include small particle size, preferably smaller than 200 mesh, and composition which is most nearly pure calcium carbonate. If calcium content is relatively low, limestones will be effective neutralizers if they contain calcite and have a high surface area. OR 74-55

MD74-23 USE OF LIMESTONE IN AMD TREATMENT

Ford, C. T. (Bitum. Coal Res., Inc.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 205-228. This paper reports the evaluation of the limestone treatment process for all types of acid mine drainage and the results of the investigation into the use of activated carbon as an oxidation catalyst for ferrous iron to overcome one of the defects in the process. (From text) OR 74-42

MD74-24 MINE SEALING AS A CONTROL METHOD

Foreman, J. W. (Gwin, Dobson, Foreman, Inc.), Interstate Mining Compact Comm., Spring Meet., Pipestem, W. Va., by U.S. EPA, May 16, 1974. 12 pp. The types of seals discussed are air-trap seals, dry seals, hydraulic seals, and mine barriers. Regulated discharges and water diversion are also used where sealing alone is not feasible. Water transfer methods may also be used to blend acid and alkaline water where possible. Results of various mine sealing projects are discussed and sketches are attached to illustrate the different types of mine seals. OR 74-68

MD74-25 A PROGRESS REPORT—EVALUATION OF MINE DRAINAGE ABATEMENT PROJECTS IN WESTERN PENNSYLVANIA

Foreman, J. W. (Gwin, Dobson & Foreman, Inc.), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 128-132. Since 1967, 82 construction contracts for mine drainage abatement have been successfully completed in western Pennsylvania, most under a special state appropriation made in 1968. Among projects described are that at Moraine State Park, where work included deep mine sealing, surface sealing, surface mine reclamation, refuse pile removal, and well plugging; Argentine and Whiskerville Mines in Butler County where hydraulic deep mine seals were used; and the Shaw Mines Complex in Somerset County where the project included sealing of deep mine subsidence areas, excavation and installation of clay seals, surface mine reclamation and daylighting, diversion ditches, installation of deep mine hydraulic seals and grout curtains. OR 74-35

MD74-26 ELECTROCHEMICAL REMOVAL OF HEAVY METALS FROM ACID MINE DRAINAGE

Franco, N. B. and Balouskus, R. A., ECOTROL, Inc., Rept. to EPA, Environ. Protection Technol. Ser. EPA-670/2-74-023 (May 1974). 87 pp. NTIS, PB-232 764/AS. This report outlines laboratory and field studies to learn the economics of ferrous iron oxidation in a cell containing conductive particles. A 5 gal/min pilot plant was run at an actual mine site to compare results of treating a 40 and 250 ppm ferrous iron drainage at pH levels of 2 and 5. About 86% of the ferrous iron was oxidized in treating the low pH water. Conversion was lower with the pH 5 drainage due to ferric hydroxide coating the electrodes of the system. Aluminum and manganese concentrations were also decreased. Results indicate that capital and operating costs for electrochemical treatment would be higher than those for aeration. OR 74-13

MD74-27 CONTROLS ON HEAVY METALS IN SURFACE AND GROUND WATERS AFFECTED BY COAL MINE DRAINAGE: CLARION RIVER - REDBANK CREEK WATERSHED, PENNSYLVANIA

Gang, M. W. and Langmuir, D. (Pa. State Univ., Dept. Geosciences), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 39-69. In the Clarion River - Redbank Creek Watershed of northwestern Pennsylvania, waters from 6 springs, 15 wells (13 flowing abandoned oil and gas wells), and 31 surface waters were analyzed for their amounts of, and controls on major and trace constituents including Fe, Mn, Al, Zn, Co, Ni, Cu, Cr, Cd, Ag, and Pb. Fe, Mn, dissolved solids, acidity, and trace metal levels increase with increased amounts of stripping, and with decreased amounts of limestone strata. Regression equations relate Zn to the other trace metals in these streams and allow prediction of trace metal values in the streams from stream discharge or from limited water quality data. (Authors' abstract modified) OR 74-31

MD74-28 ENVIRONMENTAL PROTECTION IN SURFACE MINING OF COAL

Grim, E. C. and Hill, R. D. (EPA Natl. Environ. Res. Cent., Cincinnati, Ohio), Environ. Protection Technol. Ser. EPA-670/2-74-093 (Oct. 1974). 277 pp.+ Section X discusses acid mine drainage and its control and treatment. OR 74-59

MD74-29 HYDROLOGICAL INFLUENCES IN PREVENTIVE CONTROL OF MINE DRAINAGE FROM DEEP COAL MINING

Gunnett, J. W., M.S. Thesis, Pa. State Univ., Dept. Miner. Eng., 1974. 89 pp.+ An active, deep mine in Clearfield County, Pennsylvania was studied to determine the effects of the geology, hydrology, and mineralogy of the area on the quality and quantity of the mine water discharge. Determination of fracture traces and surface and underground jointings indicated that they correlated with seepage into the mine in "uncaved" workings. Tabulations include flows from the mine drainage treatment pond in 1971 and in June, July and August 1972; and results of analyses of waters from representative areas of the mine, sampled in September 1972. A procedure for determining the most effective control of drainage from coal mines was suggested. OR 74-66

MD74-30 DEVELOPMENT OF A HIGH PRODUCT WATER RECOVERY SYSTEM FOR THE TREATMENT OF ACID MINE DRAINAGE BY REVERSE OSMOSIS

Gupta, M. K., Envirex Inc., R&D Progr. Rept. No. 939 to U.S. Office Saline Water (1974). 51 pp. NTIS, PB-230 756. Extensive laboratory feasibility studies were conducted on Proctor #2 mine waters of the Hollywood site of Penn. State Univ. Brines saturated with calcium sulfate were produced via a portable RO unit employing hollow fiber B-9 membranes for a multitude of neutralization and softening tests. Effects of $CaSO_4$ seeding, sludge recycling, and addition of sequestering agents such as "Calgon" were also studied. Hybrid RO systems in which a tubular RO unit was placed down stream of the hollow fiber RO unit were evaluated for supersaturation of the AMD brines. (From author's abstract) OR 74-63

MD74-31 EFFLUENT LIMITATION GUIDELINES AND STANDARDS

Hall, E. P. (U.S. EPA, Office Water & Hazardous Materials), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 1-4. The author gives the background for the development of Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972. There is discussion of the five separate sections of the act which are the basis for EPA to develop effluent limitations, guidelines and standards to be achieved by July 1, 1977. The author describes the procedures to be followed to promulgate regulations and indicates where the regulations will affect the coal industry. OR 74-27

MD74-32 COAL HUMATES FOR THE REMOVAL OF WATER POLLUTANTS ASSOCIATED WITH THE USE OF COAL

Harlan, S., Green, J., and Manahan, S. (Univ. Mo., Dept. Chem.), ACS Div. Environ. Chem. Preprints 14 (1), 282-284 (1974). Laboratory studies showed that specially treated coal would effectively remove both ferric and ferrous iron as well as cadmium, copper and sulfuric acid from water. OR 74-52

MD74-33 THE RECOVERY OF STREAMS STRESSED BY ACID COAL MINE DRAINAGE

Herricks, E. E. (1) and Cairns, J., Jr. (2) [(1) Union Carbide Corp. and (2) Va. Polytechnic Inst. & State Univ.], Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 11-24. The complex interactions between physical, chemical, and biological systems within the Indian Creek Watershed in southwestern Pennsylvania, as they relate to the recovery of the stream, are discussed. The study shows that effects of acid mine drainage can be moderated and that waste discharges can be assimilated by streams if the physical, chemical and biological limitations are known and applied. (Authors' Summary modified) OR 74-29

MD74-34 REHABILITATION OF STREAMS RECEIVING ACID MINE DRAINAGE

Herricks, E. E. and Cairns, J., Jr., Va. Polytech. Inst. State Univ., Water Resour. Res. Cent., Bull. 66 (undated). 284 pp. This study, carried out in 1971-1972,

MD74-34 (continued)

investigates the effect of mine drainage on the numbers and varieties of organisms that live on the bottom of the streams. Experiments for the study were carried out in Mill Creek, a tributary of the Roanoke River, and in two streams in Pennsylvania that receive acid mine drainage, Indian Creek and Little Scrubgrass Creek. Data collected determine the time and distance needed for artificial and natural recovery of the bottom-stream population. These data can be used to select proper rehabilitation procedures and to help locate mining sites that will least affect the watershed of the area around coal mines. (From authors' Preface) OR 74-26

MD74-35 PREPLANNING MINING OPERATIONS TO REDUCE THE ENVIRONMENTAL IMPACT OF MINE DRAINAGE ON STREAMS

Herricks, E. E. (1), Cairns, J., Jr. (2), and Shanholtz, V. O. (2) [(1) Union Carbide Corp. (2) VPI & SU], Water Resour. Problems Related to Mining, Am. Water Resour. Assoc., Proc. No. 18, June 1974. pp 1-11. The mining operation is planned to keep the assimilative capacity of streams in mined areas at a high level. The four step process recommended includes mapping the watershed area and noting constraints to mining; incorporating the area to be mined on the planning map; baseline data acquisition, and selecting permanent sites for water quality and biological sampling; and continuous data acquisition to monitor the mining operation. OR 74-83

MD74-36 OVERVIEW OF USE OF CARBONATE ROCKS FOR CONTROLLING ACID MINE DRAINAGE

Hill, R. D. (U.S. EPA, Mining Pollution Contr. Branch), Tenth Forum on Geology of Industrial Minerals, Ohio State Univ., Columbus, Ohio, April 18, 1974. 8 pp.+ This paper discusses the sources of acid mine drainage and formation of acid from pyrite. Treatment methods are discussed including the advantages of lime, limestone, and the merits of using both. Diagrams of lime treatment plants are included as well as several limestone treatment layouts. Figures are given on the amounts of lime and limestone currently in use for neutralizing acid mine water. OR 74-3

MD74-37 UNDERGROUND MINE DRAINAGE POLLUTION CONTROL

Hill, R. D. (U.S. EPA, Mine Drainage Control Branch), Interstate Mining Compact Comm., Spring Meet., Pipestem, W. Va., by U.S. EPA, May 16, 1974. 14 pp. The problems of preventing acid mine drainage by mine sealing are discussed and studies on various methods of sealing are described. There are ten references to recent work and one on the mine sealing program of the thirties. OR 74-69

MD74-38 REVERSE OSMOSIS-NEUTRALIZATION PROCESS FOR TREATING MINERAL CONTAMINATED WATERS

Hill, R. D., Wilmoth, R. C., and Scott, R. B. (to United States of America rep. by Administrator, EPA), U.S. Pat. 3,795,609 (March 5, 1974). 6 pp. Acid mine drainage is pretreated and then processed by reverse osmosis. The result is a stream containing at least 90% of the feed water. The remainder is a brine stream containing a heavy concentration of mineral contaminants. This fraction is then treated to produce a sludge product and a recycle brine stream which is returned to the reverse osmosis treatment. Ultimate products of the process are purified water and a small volume of inert sludge. OR 74-8

MD74-39 EFFLUENT POLISHING IN BASE METAL MINE DRAINAGE TREATMENT

Huck, P. M., Kucharski, J., and Le Clair, B. P. (Wastewater Tech. Cent., Environ. Canada), Natl. Coal Assoc./Bitum. Coal Res., Inc., Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 286-301. Effluent from base metal mine drainage has been treated by the conventional method of neutralization, precipitation, and clarification may contain higher concentrations of copper, zinc, lead and

MD74-39 (continued)

iron than are considered acceptable. Consequently, a laboratory and pilot plant program for evaluating several methods of polishing effluents was carried out. The initial processes studied were ion exchange, carbon adsorption, coprecipitation, and reaction with calcium, magnesium, or aluminum. Other methods studied which showed promise for reducing effluent metal content were polymer addition and sand filtration. Sulfide addition was considered to have little advantage over conventional neutralization with lime unless plant conditions are non-ideal. OR 74-46

MD74-40 EVALUATION OF ION EXCHANGE PROCESSES FOR TREATMENT OF MINE DRAINAGE WATERS

Intorre, B. J., Kaup, E. G., Hartman, J. L., Feiler, H. D., and Szostak, R. M., Burns and Roe Construction Corp., R & D Prog. Rept. 74-925 to Office of Saline Water, U.S. Dept. Int., Jan. 1974. 183 pp. NTIS, PB-227 734. This report describes laboratory and pilot scale work on modified Desal, Sul-biSul, and conventional ion exchange processes to evaluate their performance on acid mine drainage feed waters. The purpose was to produce potable water from acid mine waters and to determine the economics. The demonstration plant was located at Hawk Run, Pennsylvania. The modified Desal process can produce potable water from acid mine drainage whereas the Sul-biSul process is not effective with acid mine waters, but works on alkaline feed water. Extensive data are tabulated and charted. Regeneration and waste disposal operations cause some problems. OR 74-14

MD74-41 UNSUSPECTED SOURCE OF WATER POLLUTION IN SOUTHWESTERN PA.

Khoury, S. G. (1) and Hipwell, R. M. (2) [(1) Dames and Moore, (2) Univ. Pittsburgh], Pa. Geol., Oct. 1974. pp 2-4. The large volume of water required for greens and tees on a golf course, built on about 6% stripped land, drains into an underlying coal seam which has also been mined. The water eventually emerges as acid mine drainage. It is suggested that golf courses built over shallow mines be designed with a closed drainage system that allows water recycle. OR 74-62

MD74-42 ACID STRIP MINE LAKE RECOVERY

King, D. L., Simmler, J. J., Decker, C. S., and Ogg, C. W. (Univ. Missouri), J. Water Pollut. Contr. Fed. 46 (10), 2301-2315 (1974). Clays and associated aluminum are identified as buffers in acid surface mine lakes. Also, organic material plays a necessary role in establishing conditions for sulfate reducing bacteria whose action results in evolution of hydrogen sulfide gas. The interaction between these two systems with other complex factors in the recovery of surface mine lakes is discussed. The authors suggest accelerating recovery of acid surface mine lakes by addition of organic waste in such a way that aeration could be used to slow the rate of bacterial action if H_2S were being evolved more quickly than it could be dispersed. OR 74-24

MD74-43 THE USE OF AMBERLITE® ION EXCHANGE RESINS IN TREATING ACID MINE WATERS AT PHILIPSBURG, PENNSYLVANIA

Kunin, R. (1) and Demchalk, J. J. (2) [(1) Rohm and Haas Co. (2) Pa. Dept. Environ. Resour.], Natl. Coal Assoc./Bitum. Coal Res., Inc., Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 302-311. An ion exchange process has been used to make potable water from acid mine drainage at a demonstration plant operated by the Commonwealth of Pennsylvania since early in 1973. The plant was designed for 500,000 gpd, increased to 800,000 gpd, and it is expected that the capacity can be further increased. The ion exchange resin removes sulfate and chloride in the stream. The effluent contains calcium, magnesium, iron, manganese, and aluminum which are removed by degasification, aeration and softening. Each section of the plant is described and the methods of coping with the problems relating to each one are discussed. OR 74-47

MD74-44 MINE DRAINAGE POLLUTION CONTROL - A STATE VIEWPOINT

Kyle, G. E. (Pa. Dept. Environ. Resour.), Interstate Mining Compact Comm. Spring Meet., Pipestem, W. Va., by U.S. EPA, May 16, 1974. 6 pp. Mine drainage control projects of the Pennsylvania Department of Environmental Resources have included several mine sealing methods, different types of water diversion, daylighting, inundation, and neutralization. OR 74-70

MD74-45 STUDIES IN THE TREATMENT OF COAL MINE DRAINAGE BY BIOCHEMICAL IRON OXIDATION AND LIMESTONE NEUTRALIZATION

Lovell, H. L., Pa. State Univ., Coll. Earth Miner. Sci., Spec. Res. Rept. SR-98 to Pa. Dept. Environ. Resour., Feb. 28, 1974. 110 pp. This is a continuation of studies at the Hollywood Experimental Mine Drainage Treatment Facility. Section I covers the biochemical iron oxidation-limestone neutralization system for the treatment of coal mine drainage. This system uses a rotary limestone reactor to produce limestone slurry. Details of the lagoon storage of water to be treated and the treating equipment are given. Also tabulated are power requirements and costs and water analyses showing the effectiveness of the system. Section II discusses the biochemical oxidation of iron II in a surface reactor. A plastic cover over the reactor controlled the water temperature in winter. Water and sludge analyses are recorded. Section III covers the use of waste limestone dust, called hot lime, as a treating agent; and gives analyses showing results of treatment. OR 74-18

MD74-46 HYDROGEOLOGICAL INFLUENCES IN PREVENTIVE CONTROL OF MINE DRAINAGE FROM DEEP COAL MINING

Lovell, H. L. and Gunnett, J. W. (Dept. Miner. Eng.), The Pa. State Univ., Spec. Res. Rept. SR-100, to Pa. Dept. Environ. Resour. (1974). 89 pp. In this study of an active deep mine in Clearfield County, Pa., it was found that the major source of infiltration was the caved areas, and that jointing associated with surface fracture traces was the primary infiltration route in uncaved portions of the mine. Further, mine waters were subject to degradation while draining to sumps and during retention in pools. Recommendations made for diverting ground water flow and for changes in procedure for handling drainage within the mine should result in a significant reduction in the quantity, as well as improvement in the quality, of mine drainage. (From authors' abstract) OR 74-74

MD74-47 DEEP MINE POLLUTION - SOLVING THE HOLE PROBLEM

Loy, L. D., Jr. (Skelly and Loy, Engineers, Consultants), Interstate Mining Compact Comm. Spring Meet., Pipestem, W. Va. by U.S. EPA, May 16, 1974. 8 pp. In reviewing the state of the art, the author points out that although only a small part of the needed technology for mine drainage abatement has been developed, that technology should be utilized to the fullest extent to facilitate further development. New abatement methods discussed are alkaline overburden, mine roof collapse, slurry trenching, and alkaline surface mine regrading. Emphasis for research and development programs are placed on Daylighting-Total Resource Recovery, effects of controlling water flow, defining mine workings, and further studies on development and use of mine seal. OR 74-71

MD74-48 DESCRIPTION OF NEW, INNOVATIVE AND THEORETICAL MINE DRAINAGE ABATEMENT TECHNIQUES

Loy, L. D., Jr. (Skelly and Loy, Engineers, Consultants), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 146-159. A number of different material handling methods which can be used to minimize and control mine drainage are described and diagramed. These include use of refuse for roadbed material; reuse of treatment plant effluent either in coal cleaning or outside the plant in other uses such as irrigation; use of an evaporation pond; a regulated discharge from lagoons and settling ponds when receiving streams can assimilate waste water; swale regrading for water diversion;

MD74-48 (continued)

alkaline regrading; slurry trench; preplanned flooding of underground mine; borehole seal; gunite mine seal; and clay type mine seal against low water pressure. OR 74-37

MD74-49 QUALITY OF EFFLUENTS FROM COAL REFUSE PILES

Martin, J. F. (U.S. EPA, Natl. Environ. Res. Cent., Cincinnati, Ohio), Natl. Coal Assoc./Bitum. Coal Res., Inc.,First Symp. Mine Preparation Plant Refuse Disposal Preprints, Louisville, Ky. (1974). pp 26-37. Effluents from refuse piles in Pennsylvania, West Virginia, Kentucky, and Indiana were sampled in the spring of 1974 and results of water analyses are tabulated and compared with analyses from the literature including analyses of effluents in Illinois. Amounts of metal ions and acidity and alkalinity are related to the coal seams and their geochemical characteristics. Pollution is also related to refuse pile construction. Suspended sediment seems to be more of a pollution problem than acid or metals in an area covering southern West Virginia and eastern Kentucky. OR 74-51

MD74-50 pH AND SOLUBLE CU, NI AND ZN IN EASTERN KENTUCKY COAL MINE SPOIL MATERIALS

Massey, H. F., Soil Science 114 (3), 217-221 (1972). On the basis of studies with 4 spoil materials, the effects of liming on solution concentrations of Zn, Cu and Ni can be roughly estimated from pH measurements. More accurate estimates could be obtained by making a few determinations on each spoil materials. Of the 3 elements studied, Ni appeared to be most likely to remain in the soil solution in toxic amounts once the pH has been adjusted to a point which would otherwise be satisfactory for plant growth. (From author's Summary) OR 72-84

MD74-51 STUDIES OF LIME-LIMESTONE TREATMENT OF ACID MINE DRAINAGE

McDonald, D. G., Yocum, H., and Grandt, A. F. (Peabody Coal Co.), Natl. Coal Assoc./ Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 229-245. A joint study by EPA and Peabody Coal Co. on treating large volumes of acid mine drainage at the Will Scarlet Mine in Illinois was carried out from March 1973 to February 1974. A full scale water treatment plant processed accumulated mine water which had been diverted to inactive pits and closed basins. The main objective was to determine the most economical method of treating large volumes of AMD. Neutralization was done using limestone and lime alone and in combination. Factors evaluated were effects of detention time, sludge recirculation, and neutralizing agent. The most economical method of treatment was a combination of lime and limestone treatment lines in series, both with sludge recirculation. OR 74-43

MD74-52 WATER POLLUTION POTENTIAL OF MINE SPOILS IN THE ROCKY MOUNTAIN REGION

McWhorter, D. B., Skogerboe, R. K., and Skogerboe, G. V. (Colo. State Univ.), Natl. Coal Assoc./Bitum. Coal Res. Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 25-38. The chemical characteristics of spoils produced by surface mining of coal at the Edna Mine in northwest Colorado and the Navajo Mine in New Mexico were determined using a saturated soil paste method. The soluble salts in both spoils and the amount of water necessary to leach them were also determined. Since water availability at the Navajo site is very limited, the possibility of significant percolation through the bulk of the spoil banks is remote except where runoff is concentrated in closed depressions. Some salts will be removed by surface runoff. More water is available at the Edna Mine, and in-stream water quality variations were observed and related either to increased contribution of mine drainage or to dilution of mine drainage by increased snow melt at higher elevations. Sampling was carried out at eight stations either on the Trout River or on drainage to it. Samples were also collected from groundwater seeps and observation wells. (Authors' Summary and Conclusions modified) OR 74-30

MD74-53 SEEPAGE AND MINE BARRIER WIDTH

Miller, J. T. (1) and Thompson, D. R. (2) [(1) Rummel, Klepper and Kahl, Consulting Engineers and (2) Pa. Dept. Environ. Resour.], Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 103-127. The question of whether or not coal barriers commonly left in mines for safety are sufficient to restrict drainage is investigated. Ground water availability is discussed. Also presented are permeability data which were gathered for seepage analysis investigations at various sites in five different geologic settings. Gross data relationships are indicated and briefly discussed in an effort to gain insight into the nature of seepage at depth. Selected well data are presented and randomly chosen drillers' logs are tabulated to illustrate rock type variations in a limited stratigraphic section. Values of permeability need to be related to depth below the ground surface, to rock types, and to fracture characteristics, in order to determine the nature of flow around and through a coal barrier. (Adapted from text)
OR 74-34

MD74-54 MIXERS AGITATE POWDERED LIME TO NEUTRALIZE ACID WATER DRAINAGE

Coal Age 79 (12), 80 (1974). Treatment of acid water drainage from surface mines in Consolidation Coal Company's Central Division, Cadiz, Ohio is described. OR 74-58

MD74-55 OAKMONT MINE TRIES PVC PIPE--AND LIKES IT

Coal Age 79 (12), 73-74 (1974). A fast coupling ductile PVC pipe is being used to pump acid mine water into an abandoned section of the mine for permanent impoundment. Since pumping is not continuous and "yellow boy" builds up when water is stationary for sometime the pipe must be cleaned out about every six weeks. OR 74-57

MD74-56 CHEMICAL IONIC EQUILIBRIUM RELATIONSHIPS INVOLVED IN MINE DRAINAGE NEUTRALIZATION AND TREATMENT

O'Brien, W. S. (1), Galli, A. F. (2), and Wen, C.-Y. (2) [(1) Southern Ill. Univ., Thermal Environ. Eng. Dept. and (2) W. Va. Univ., Chem. Eng. Dept.], Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 192-204. The theoretical mathematical model which simulates mine drainage neutralization was derived for acidic-iron water with measurable properties such as total sulfate, acidity, and ferrous-ferric iron as independent variables and is based on the various ionic species reaching aqueous equilibrium when treated with the neutralizing agent being studied. When the model was used to simulate $Ca(OH)_2$ neutralization of acid water of a given composition, computed values of pH versus the amount of $Ca(OH)_2$ added matched experimental data quite well. Other problems in mine drainage neutralization being studied by this model include the effect of oxidation of ferrous iron on the determination of acidity; the characterization of sludges from mine drainage treatment; and the carbonate neutralization process. OR 74-41

MD74-57 ORSANCO IN REVIEW 1974

Ohio River Valley Water Sanitation Commission, Ann. Rept., Cincinnati, Ohio, 1974. 26 pp. The annual report of the Commission surveys the activities in 1974 and summarizes the results of the monitoring program on the Ohio River and its main tributaries. OR 74-81

MD74-58 PLUGGING OF PERMEABLE MATERIALS

Parks, C. F. and Goddard, J. E. (to the Dow Chemical Co.), Can. Pat. 941,600 (Feb. 12, 1974). 11 pp. Organic compounds, particularly tannins or lignins, are reacted with an acidic aqueous solution containing multivalent metal cations (e.g. acid mine water) to form precipitates in a porous material. This plugging effect prevents the movement of acidic underground waters. OR 74-73

MD74-59 STOWING IN ABANDONED MINES FOR DRAINAGE CONTROL

Patterson, R. M., Interstate Mining Compact Comm. Spring Meet., Pipestem, W. Va., by U.S. EPA, May 16, 1974. 7 pp. The use of the Dowell hydraulic backfilling technique in filling mine voids is suggested as a method of controlling water entering abandoned mines. It is suggested that the addition of water swellable polymers to the slurry will result in a tight seal of the mine void area. A demonstration project of the method is recommended. OR 74-72

MD74-60 EVALUATION OF PROTOTYPE CRUSHED LIMESTONE BARRIERS FOR THE NEUTRALIZATION OF ACIDIC STREAMS

Pearson, F. H. and McDonnell, A. J., Inst. Res. Land Water Resour., The Pa. State Univ., Res. Publ. No. 80, June 1974. 101 pp. NTIS, PB-234 551. At four prototype limestone barriers that had been constructed to neutralize acidic streams, analyses showed that the pH of stream water was increased by up to 3 pH units at low streamflow, to pH 7 or above, demonstrating that limestone barriers are capable of renovating acidic streams to the point that normal aquatic life can be restored. OR 74-23

MD74-61 NEUTRALIZATION OF ACIDIC WASTES BY CRUSHED LIMESTONE

Pearson, F. H. and McDonnell, A. J. (Penn. State Univ., Dept. Civil Eng.), Penn. State Univ., Inst. Res. Land Water Resour., Res. Publ. No. 79 (June 1974). 157 pp. Summarized in "Chemical kinetics of neutralization of acidic water by crushed limestone," in Water Resour. Problems Related to Mining, Am. Water Resour. Assoc. Proc. Ser. No. 18, 1974. pp 85-98. In these laboratory studies, dilute sulfuric acid solutions, pH from 2 to 7, were circulated over limestone in the size range of 2-1/2 to 4 inches to determine the kinetics of the two rate limiting neutralization reactions. The rate of neutralization is controlled by reaction between hydrogen ions and limestone when the pH is low and by the evolving of carbon dioxide from solution above approximately pH 5. Rate constants for the reactions were found to be functions of temperature, ionic strength, and water turbulence, and for the first reaction, bicarbonate ion. The addition of salts of iron, aluminum and manganese to the acid water and a thin clay coating on the limestone were found to have no observable effect on kinetics. Also, the experimental data were shown to fit the mathematical model of the system which was constructed from two linked differential equations governing the hydrogen ion concentration and the balance of carbonic species in the water being neutralized. Surface area of the crushed stone was estimated. (Authors' conclusion adapted) OR 74-64

MD74-62 ACID MINE DRAINAGE AS A CHEMICAL COAGULANT FOR TREATMENT OF MUNICIPAL WASTEWATER

Pearson, F. H. and Nesbitt, J. B. (Pa. State Univ., Dept. Civil Eng.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 181-191. Since iron salts will remove phosphorous from municipal waste water, this study was set up to evaluate acid mine drainage as a source of iron for phosphorous removal. Samples were taken from three locations in Pennsylvania where a source of AMD was near enough to waste water treatment plants to consider combined treatment. Laboratory studies evaluated a range of conditions of pH and mixing ratio of AMD to waste water. Analyses of both raw waters and of the effluent from combinations were made for turbidity, total phosphorous, BOD, total organic carbon, ferrous iron, total iron, aluminum sulfate, and acidity or alkalinity. Some of the authors' conclusions are (1) at pH 8, the treatment process was just about optimal in reducing total phosphorous, ferrous iron, and turbidity; (2) when a significant part of the iron in acid mine drainage was in the ferric form combined treatment was ineffective; (3) in the economic feasibility studies, it was shown that there is a maximum distance for which it is economical to pump AMD to a waste treatment plant. OR 74-40

MD74-63 LIMESTONE SELECTION FOR PERMEABLE PLUG MINE SEALS

Penrose, R. G., Jr. (Cyrus Wm. Rice Div. - NUS Corp.), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 133-145. A laboratory project was conducted to evaluate several limestone types and sizes as possible permeable plug mine seals. Several additives were also studied. Three synthetic mine waters, high ferric, high ferrous, and a combination of ferric and ferrous iron, were allowed to percolate through sample filled columns. Among the conclusions are that limestone aggregate plugs are a feasible means of sealing underground mines which discharge water with ferric iron; the type of limestone found in previous tests to best neutralize acid mine waters had the best overall performance; the 3/8 inch to dust grade of stone was the most satisfactory size tested; increasing fines content of commercially available stone to twice the original amount results in improved performance; and high placement densities are essential for satisfactory plug performance. OR 74-36

MD74-64 SOLID WASTE DISPOSAL, FINAL REPORT

Phillips, N. P. and Wells, R. M., Radian Corp., Rept. to EPA, National Environ. Res. Cent., Research Triangle Park, N. C., EPA-650/2-74-033, May 1974. 268 pp. NTIS, PB-233 144. This publication covers many waste solids including acid mine drainage sludge. The nature of sludge, disposal techniques for sludge, sludge conditioning, dewatering techniques, sludge handling, ultimate sludge disposal are all discussed. Actual plant case studies of Whetstone Portal Treatment Plant, Edgell Treatment Plant, and Levi Moore Treatment Plant of Consolidation Coal Company are also included. OR 74-21

MD74-65 GROUND WATER QUALITY AT A STRIP-MINE RECLAMATION AREA IN WEST CENTRAL ILLINOIS

Pietz, R. I., Peterson, J. R., and Lue-Hing, C. (Metropolitan San. Dist. Greater Chicago), Natl. Coal Assoc./Bitum. Coal Res., Inc., Second Res. Applied Technol. Symp. Mined-Land Reclamation Preprints, Louisville, Ky. (1974). pp 124-144. Twenty-four groundwater monitoring wells were established both on non-disturbed and on surface mined land in Fulton County, Illinois, to provide baseline environmental data for twenty-three chemical characteristics. These lands are being reclaimed to agriculture by applications of digested sewage sludge from Metropolitan Sanitary District of Greater Chicago. Water samples were analyzed monthly from December 1971 to December 1973. Data show that mine spoil groundwaters have higher metal contents as well as greater concentrations of chlorine, sulfate, and Kjeldahl nitrogen. Also groundwaters of the mined areas have a greater number of significant monthly, seasonal, and well-to-well variations in the chemical constituents analyzed for. Data from a typical mined area monitoring well were used to explore the possibility of using the monitoring data for evaluation of future groundwater quality. OR 74-86

MD74-66 PLANT AN ACID-LOVING PLANT TO START NEW WORLDS OF LIFE IN ACID STREAMS

Coal Age 79 (1), 78 (1974). Penn State's Assistant Professor, Dr. Richard Wagner, has observed an acid-loving plant, Eleocharis acicularis, that grows in quiet pools or where an acid stream has only a slight downhill grade. The plant is a bright green and has been known since 1908. As yet, there are no commercial suppliers, but it is easy to obtain from several natural locations. OR 74-1

MD74-67 REMOTE SENSING OF COAL MINE POLLUTION IN THE UPPER POTOMAC RIVER

Ambionics, Inc., Final Rept. to NASA Langley Res. Cent., Contract No. NAS-1-12673 (undated). 66 pp. NTIS, N74-34817. Conclusions from the study are that the combined approach of ERTS imagery, corresponding aircraft photography, and ground study are needed for an effective program of continuous mine acid pollution monitoring; and that methods of detecting mine acid polluted water from aircraft imagery, and methods of monitoring surface mine activity from ERTS imagery have been developed. OR 74-76

MD74-68 ACID MINE DRAINAGE QUANTITY AND QUALITY GENERATION MODEL

Ricca, V. T. and Chow, K. (Ohio State Univ.), Trans. AIME 256, 328-336 (1974). AIME Ann. Meet., Chicago, Feb. 1973, Preprint 73AG106. The authors present a computer model which predicts average daily mine water discharge, acid loading, and average daily flow in receiving streams. They show its application to the McDaniels mine in southeastern Ohio. OR 74-56

MD74-69 REMOVAL OF MANGANESE FROM MINE WATERS

Rozelle, R. B. and Swain, H. A., Jr. (Wilkes Coll.), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 357-369. The kinetics of the oxidation of manganese (II) ion in solution by ozone, hypochlorite ion, and by chlorine gas were studied in a static system. It was found that ozone and hypochlorite ion can reduce manganese solution concentrations by oxidation of manganese (II) from above 10 ppm to below 0.1 ppm at practical pH's and temperatures and in relatively short times (≈1-5 min.). The reaction of chlorine was found to be so slow as to be not practical. Costs of ozone and hypochlorite ion treatment are compared. (From authors' abstract) OR 74-50

MD74-70 GYPSUM SCALING IN AMD TREATMENT PLANTS - AN ABSOLUTE INDEX OF SCALING POTENTIAL

Selmeczi, J. G. (1) and Miller, J. P. (2) [(1) Dravo Corp. and (2) Univ. Pittsburgh, Dept. Civil Eng.], Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 262-285. This paper describes how to calculate the gypsum scale-forming potential of treated mine drainage so that the treatment procedure can be adjusted to minimize this problem. OR 74-45

MD74-71 SHALLOW GROUND WATER IN SELECTED AREAS IN THE FORT UNION COAL REGION

Ground-water Subgroup, Water Work Group, Northern Great Plains Resour. Program, U.S. Geol. Surv. Open File Rept. 74-371 (1974). 72 pp.+ NTIS, PB-244 848/8WP. The Gascoyne area in North Dakota, the Gillette area in Wyoming, and parts of the Birney-Decker area in Montana were surveyed to give a preliminary indication of the effect of surface mining on water supply and quality in the Fort Union coal region. The hydrogeological information available showed that while supply from shallow aquifers may be interrupted until mines are backfilled, supply from deeper aquifers will probably not be affected. Minimal discharge is expected from mining. Tabulated data include identification of wells and results of analyses of water from selected wells in the area. Ground water generally has considerable amounts of dissolved solids and leachate studies of coal overburden indicate that drainage through spoils would augment the dissolved solids level. Studies needed to define further the effects of mining on the regional ground water system are discussed. OR 74-78

MD74-72 RIVERINE RECREATIONAL DEVELOPMENT-MATHEMATICAL MODELING

Shane, R. M., Carnegie-Mellon Univ., Final Rept. (1974). 109 pp. NTIS, PB-238 350. For assessing the availability and use of water-based recreation on the Allegheny River close to Pittsburgh, two computer models were developed. One model evaluated effects of acid mine drainage and its abatement on a branched river system and was based on a generally applicable water quality computer model developed for the state of Illinois. This model was applied to the Kiskiminetas River, the most severe source of mine drainage for the Allegheny River. It showed that clean-up of the Loyalhanna Creek would have only local effects and that pollution from the Conemaugh River and other mine drainage sources along the Kiskiminetas would be affected only slightly. A survey of available water quality data for the Allegheny River in the urban section showed that it was suitable mainly for boating and general fishing. The second model was a participation rate model based on a number of socio-economic factors with the primary source of data a 1967 Home Interview Survey conducted by the Southwestern Pennsylvania Regional Planning Comm. Although user age and income

MD74-72 (continued)

were shown to be important factors in recreational use, the importance of accessibility and water quality could not be determined from the data available. OR 74-75

MD74-73 SLIPPERY ROCK CREEK ACID MINE WASTE STUDIES

Academy of Natural Sciences of Philadelphia, Rept. to Appalachian Regional Comm., Contract 68-24/RP-012, April 1974. 111 pp. This comprehensive study of Slippery Rock Creek was made to determine the effects of acid mine drainage on aquatic life. Extensive data were taken at 6 individual stations, water analyses were recorded in detail, and the aquatic life at each location was surveyed. The results of these studies show that practically all species are eliminated when pH drops below 6 and when iron floc is present. OR 74-15

MD74-74 ACID PRODUCTION IN MINE DRAINAGE SYSTEMS

Smith, M. J. (Wright State Univ.), in "Extraction of Minerals and Energy: Today's Dilemmas," R. A. Deju, Ed., Ann Arbor: Ann Arbor Science Publishers, Inc., 1974. pp 57-75. This chapter discusses mine drainage formation from the standpoint of microorganisms which are believed to promote oxidation reactions with pyrite. Indications are that little is known about the actual behavior of Thiobacillus thiooxidans and Thiobacillus ferrooxidans because of great diversity of conflicting data. OR 74-6

MD74-75 MINE SPOIL POTENTIALS FOR SOIL AND WATER QUALITY

Smith, R. M., Grube, W. E., Jr., Arkle, T., Jr., and Sobek, A., W. Va. Univ. (College Agr. & Forestry, Div. Plant Sci.), EPA, Environ. Protection Technol. Ser. EPA-670/2-74-070 (Oct. 1974). 302 pp. NTIS, PB-237 525/AS. The purpose of this detailed study of coal overburden and coal related strata is to enable coal surface miners to plan the overburden placement in reclamation so that acid runoff is reduced and the most favorable soils are available for plant growth. Specific suggestions are made for dealing with overburden associated with particular coal seams. The results of the extensive overburden sampling and testing program in West Virginia are tabulated, and the step-by-step analytical procedures used are presented so that they can be followed by others carrying out similar studies on lands to be mined. OR 74-25

MD74-76 NATURAL BIOLOGICAL CONTROL OF THE SALT MARSH MOSQUITO IN THE ACID MINE DRAINAGE SWAMPS OF WESTERN KENTUCKY

Spencer, H. T., Baker, C. D., Leuthart, C., and Shawler, M. E. (Univ. Louisville, Speed Scientific School), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 172-180. The salt marsh mosquito heavily infested the acid mine drainage swamps of Clear Creek Watershed in western Kentucky in 1953, the condition becoming epidemic in 1956. Intensive spraying programs were initially used for control since draining the swamps was not economically feasible. Also, an extensive levee system made 300 acres of former breeding ground available for farming. A water plant, Chara, is now so abundant that it acts as a mosquito control agent by producing high levels of dissolved oxygen which seems to prevent development of mosquito larvae. OR 74-39

MD74-77 ACID TOLERANCE IN THE BROWN BULLHEAD ICTALURUS NEBULOSUS (LE SUEUR)

Sprague, B. E., M.S. Thesis, W. Va. Univ., 1974. 98 pp. Fish taken from the Monongahela River and Cobun Creek were exposed to various acid levels using water made up to simulate Monongahela River water. Water temperature also varied. Results tend to indicate that the bullhead is one of the most acid tolerant species in the Monongahela River. Mortality with increasing acidity was mainly due to mucus formations on the gill filaments. Acid tolerance seemed to be greater at lower temperatures. OR 74-77

MD74-78 SURFACE MINE WATER QUALITY CONTROL IN THE EASTERN KENTUCKY COAL FIELDS

L. Robert Kimball, Consulting Engineers, Rept. to Ky. Dept. Natural Resour. Environ. Protection and Appalachian Regional Comm., ARC-71-66-T5 (March 1974). 92 pp.+ This report is concerned with acid mine drainage and other forms of chemical water pollution attributed to surface mining in the Eastern Kentucky Coal Field and gives primary emphasis to identifying coal seams with the highest acid producing potential. The parameters, criteria, and methodology developed and used to achieve this end are described. The research effort included a general evaluation of existing water quality data for all the major drainage basins in the Eastern Kentucky Coal Field, followed by a concentrated study in the Kentucky, Big Sandy, and Cumberland River Basins. (Adapted from Summary) OR 74-10

MD74-79 HYDROLOGIC STUDY OF A RECLAIMED SURFACE MINED AREA ON THE BLACK MESA

Thames, J. L., Patten, R. T., and Crompton, E. J. (Univ. Ariz.), Natl. Coal Assoc./ Bitum. Coal Res., Inc., Second Res. Applied Technol. Symp. Mined-Land Reclamation Preprints, Louisville, Ky. (1974). pp 106-116. Two 5-acre watersheds, 3/4 mile apart, one on recontoured mined land and one on undisturbed land, were monitored in this study of water availability and quality in the arid southwest. There was no runoff from rain in the study time reported. However, from about the same amount of snowfall there was much greater runoff from the undisturbed area than from the mined area. Water quality analyses showed that while runoff water from the mined area had a higher content of salts than runoff from the unmined area, it was somewhat similar to local municipal water supplies and had lower salt content than water used for irrigating cropland and orange groves in the region. OR 74-87

MD74-80 ACID MINE WATER TREATMENT PROCESS

Treharne, R. W. and Wright, D. E. (Kettering Sci. Res. Inc., Yellow Springs, O.), U.S. Pat. 3,823,081 (July 9, 1974). 5 pp. In an electrolysis cell, the acid mine water becomes basic and iron hydroxide is precipitated in the cathode compartment while sulfuric acid is concentrated in the anode compartment. The cathode and anode compartments are separated by a sand barrier. OR 74-61

MD74-81 HYDROLOGIC EFFECTS OF STRIP COAL MINING IN SOUTHEASTERN MONTANA - EMPHASIS: ONE YEAR OF MINING NEAR DECKER

Van Voast, W. A., Montana Bur. Mines Geol. Bull. 93, June 1974. 24 pp. A study of the hydrologic effects of the Decker Coal Co. surface mine showed that the total water movement into and out of the mine is about 400,000 gals/day. As mining and reclamation proceed, it is expected that the water flow through the area will decrease. If the mining cut is completely filled, maximum water-level recoveries will result but minimum recoveries will occur if the cut is left completely unfilled. Extensive flow rate and chemical data are included. Several maps give the details of the watershed area. OR 74-88

MD74-82 WATER QUALITY ANALYSIS FOR SAMPLES TAKEN AT EASTERN KENTUCKY SURFACE COAL MINES VISITED DURING THE FALL 1972 FIELD SURVEY

Appendix G in "Design of Surface Mining Systems in Eastern Kentucky," Vol. III, Mathematica, Inc., and Ford, Bacon & Davis, Inc., Engineers, Rept. to Ky. Dept. Natural Resour. Environ. Protection and Appalachian Regional Comm., Rept. ARC-71-66-T1 (Jan. 1974). pp G1-G27. Results of analyses of 26 water samples for turbidity, alkalinity, hardness, iron, sulfate, and acidity are reported. Sampling points are identified. OR 74-80

MD74-83 EFFECT OF MINE DRAINAGE ON THE QUALITY OF STREAMS IN COLORADO, 1971-72

Wentz, D. A., Colo. Water Resour. Circ. No. 21, Colo. Water Conserv. Bd., 1974. 115 pp.+ Summarized in "Stream quality in relation to mine drainage in Colorado," in Water Resour. Problems Related to Mining, Am. Water Resour. Assoc. Proc. Ser.

MD74-83 (continued)

No. 18, 1974. pp 158-173. Since areas of ore deposits do not generally overlap coal regions in Colorado, separate surveys were made to determine the effects of coal and metal mining on stream quality. Water quality was also monitored at 13 control sites. The results of the surveys are tabulated and include field observations of water conditions and biota and results of laboratory analyses for 15 trace elements and sulfate. Since Colorado coal is mainly low sulfur, coal mine drainage is generally not acid and also does not contain the trace elements found in drainage from metal mines. OR 74-22

MD74-84 WEST VIRGINIA ACID MINE DRAINAGE STUDY IN NORTH BRANCH POTOMAC RIVER BASIN

W. Va. Dept. Natural Resour., Div. Water Resour. (1974). All acid mine drainage sources in the North Branch Potomac River Basin were mapped and measured and recommendations were made for reclamation of specific areas as well as for more effective mine drainage treatment and control. OR 74-54

MD74-85 SEDIMENT CONTROL USING MODIFIED MINING AND REGRADING SYSTEMS AND SEDIMENT CONTROL STRUCTURES

White, J. R. (1) and Plass, W. T. (2) [(1) Pioneer Fuel Co. (2) Forest Serv., USDA], Natl. Coal Assoc./Bitum. Coal Res., Inc., Second Res. Applied Technol. Symp. Mined-Land Reclamation Preprints, Louisville, Ky. (1974). pp 117-123. The sediment control program described is near Beckley, West Virginia on an area of 400 acres where three coal seams were mined. The details of the construction of three impoundments in the control system are given. Head-of-the-hollow fills, designed and built to help control drainage, each contained a French drain. Regrading and revegetation were carried on during mining. Stream flow measurements and sediment records made during the 21 month observation showed that the control system was effective in trapping storm runoff and preventing coarse size fragments and sediment from entering streams. OR 74-89

MD74-86 LIMESTONE AND LIMESTONE-LIME NEUTRALIZATION OF ACID MINE DRAINAGE

Wilmoth, R. C., U.S. EPA, Environ. Protection Technol. Ser. EPA-670/2-74-051 (June 1974). 91 pp. NTIS, PB-234 607/AS. The critical parameters affecting neutralization of ferric-iron acid mine waters were characterized in comparative studies using hydrated lime, rock-dust limestone, and a combination of the two as neutralizing agents. On the ferric-iron test water, combination limestone-lime treatment provided a better than 25-percent reduction in materials cost as compared to straight lime or limestone treatment. Significant reduction in sludge production was noted by the use of rock-dust limestone and by the use of combination treatment as compared to hydrated-lime treatment. Emphasis on optimizing limestone utilization efficiencies resulted in an increase from approximately 35-percent to 50-percent utilization. Studies using limestone that had been ground to pass a 400-mesh screen resulted in utilization efficiencies near 90 percent. (From author's abstract) OR 74-17

MD74-87 OBSERVATIONS ON IRON-OXIDATION RATES IN ACID MINE DRAINAGE NEUTRALIZATION PLANTS

Wilmoth, R. C., Kennedy, J. L., and Hill, R. D. (U.S. EPA, Crown Field Site), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 246-261. Field oxidation studies carried out for the design of EPA's Crown, W. Va., Mine Drainage Site were found to differ significantly from previous laboratory studies. An investigation included both a study of oxidation rates at nine different AMD discharges and neutralization with continuous-flow, continuous-lime-feed. OR 74-44

MD74-88 PHYSICAL AND CHEMICAL CHARACTERISTICS OF ACID-PRODUCING SANDSTONE WARRANT PREFERENTIAL STRIP AND BURIAL MINING METHODS

Wiram, V. P. (1) and Deane, J. A. (2) [(1) Amax Coal Co. and (2) Peabody Coal Co.], Natl. Coal Assoc./Bitum. Coal Res., Inc.,Fifth Symp. Coal Mine Drainage Res. Preprints, Louisville, Ky. (1974). pp 88-102. In carrying out reclamation at the Latta Mine in northwestern Green County, Indiana, Peabody Coal Company was directed to cover toxic spoil banks to prevent acid drainage. Cover had to be brought into the mined area, both increasing costs and causing a problem when a shortage of suitable material developed. To aid in alleviating this problem, the pyrite bearing sandstone was identified through an extensive sampling and analytical program. Overburden handling was then planned so that the acid forming sandstone was buried at the bottom of the advancing cast-overburden bank. In this way re-exposure of acid-producing sandstone and acid mine drainage seepage was prevented and oxidation of the pyrite was and will be held at a minimum under aqueous (ground water) conditions. OR 74-33

MD74-89 MINE DRAINAGE POLLUTION CONTROL DEMONSTRATION GRANT PROCEDURES AND REQUIREMENTS

Zaval, F. J. and Burns, R. A. (NUS Corp.), U.S. EPA, Environ. Protection Technol. Ser. EPA-670/2-74-003 (Oct. 1974). 100 pp. The report provides an interpretation of Section 107 Federal Water Pollution Control Act Amendments of 1972, "Mine Water Pollution Control Demonstrations." Procedures and requirements for grant application as well as the feasibility study, engineering, construction, operation, monitoring, and reporting for authorized projects are discussed in detail. OR 74-65

1975

MD75-1 ACID MINE WATER - A BIBLIOGRAPHY

U.S. Dept. Int., Water Resour. Sci. Inform. Cent., Washington, D.C., WRSIC 75-202 (Feb. 1975). 564 pp. The 365 entries were compiled by computer printout from U.S. Department of Interior's "Selected Water Resources Abstracts." Entries were arranged by accession number and include abstracts. Both author and subject index are permuted. Information is given for obtaining those items available from National Technical Information Service. OR 75-2

MD75-2 A FINITE ELEMENT ANALYSIS OF DISSOLVED OXYGEN DRAWDOWN AND SULFATE PRODUCTION IN STRIP MINE SPOIL DAMS DUE TO PYRITIC CHEMICAL REACTION

Amend, J. H., III, Ph.D. Thesis, Va. Polytech. Inst. and State Univ., 1975. 113 pp. University Microfilms, 75-23,691. The mathematical derivation of the model is presented. Appendixes give information on the computer program which is used to calculate solutions for a number of soil permeabilities and dissolved oxygen reaction coefficients. OR 75-21

MD75-3 WATERSHED EVALUATION AND DATA NEEDS FOR HYDROLOGIC AND ACID MINE DRAINAGE MODELING

Biemel, G. D., M.S. Thesis, Ohio State Univ., 1975. 98 pp. The data needed to develop and verify mathematical models of mine drainage polluted watersheds have been determined. Published watershed studies were found to be most deficient in data on stream flow, precipitation, and evaporation. Daily collection of this information is recommended. Information on mining parameters was also noted to be lacking. Also recommended is daily collection of water quality data for surface mine and refuse pile drainage which may respond quickly to change in surface drainage, and data for deep mine discharges which may have long-term variations. OR 75-26

MD75-4 COAL AND COAL MINE DRAINAGE

Boyer, J. F. and Gleason, V. E. (Bituminous Coal Res., Inc.), J. Water Pollut. Contr. Fed. 47 (6), 1466-1473 (1975). Fifty-six publications are listed in this review of the literature of 1974. Topics covered include treatment methods; techniques of reducing mine drainage; effects of mine drainage on stream or ground waters; and factors causing or influencing acid drainage. OR 75-44

MD75-5 A CASE STUDY OF MINE WATER QUALITY DETERIORATION, MAINSFORTH COLLIERY, COUNTY DURHAM

Cairney, T. and Frost, R. C. (Teeside Polytechnic, Great Britain), J. Hydrol. 25, 275-293 (1975). Water analyses made during various pumping cycles and pumping rates showed that generally water quality improved when flooding and dewatering were not allowed to occur. Water quality was also improved when the mine water was kept at a constant level. OR 75-18

MD75-6 A STUDY OF COAL-ASSOCIATED WASTES RESULTING FROM THE MINING PROCESSING AND UTILIZATION OF COAL: LITERATURE SURVEY--COAL ASSOCIATED WASTES (1900-1972)

Coalgate, J. L., W. Va. Univ., Coal Res. Bur., Interim Rept. No. 2 to U.S. ERDA, R & D Rept. 75 (1975). Section A: Acid Mine Drainage: Origin, Treatment and Utilization contains 112 references. OR 75-20

MD75-7 INVESTIGATION OF MINING RELATED POLLUTION REDUCTION ACTIVITIES AND ECONOMIC INCENTIVES IN THE MONONGAHELA RIVER BASIN

Doyle, F. J., Chen, C. Y., Malone, R. D., and Rapp, J. R., Michael Baker, Jr., Inc., Rept. to Appalachian Regional Comm., ARC-72-89/RPC-707 (1975). 416 pp. NTIS, PB-244 352-1WN. This study was performed to provide information on economically attractive projects to abate water pollution related to mining in order to encourage activities by the private sector. Methods suggested for reducing acid drainage from mines include control of water infiltration into mines, and surface mining and reclaiming previously deep mined areas. Case studies of these methods are presented. Pollution problems resulting from coal refuse piles are explored and the British experience in dealing with them is reviewed. A preliminary inventory of coal refuse piles in the study area is given in Appendix A. Among the suggestions for eliminating coal refuse piles and their attendant pollution problems were coal recovery; use as fill in highway and construction projects, and in surface mine reclamation; and use in manufacturing building materials. The results of a detailed laboratory investigation of the engineering properties of bituminous coal mine refuse are also included. OR 75-36

MD75-8 DRAINAGE HANDBOOK FOR SURFACE MINING

W. Va. Dept. Natural Resour. Div. Planning Develop. and Div. Reclam., Revised Jan. 1, 1975. 372 pp. The handbook gives detailed criteria for sediment control structures required for mining in West Virginia. Specifications for Valley Fill method of overburden placement are included. OR 75-37

MD75-9 ENVIRONMENTAL CONTROL AT MORTON COLLIERY IN THE NORTH DERBYSHIRE AREA

Colliery Guardian 223 (7), 257-259 (1975). Drainage from this mine was alkaline enough to be successfully treated by aeration and settling. Total iron of 140 mg per liter was reduced to less than 10 mg per liter and total suspended solids up to 200 mg per liter was reduced to less than 50 mg per liter. Aeration was accomplished by passing the discharge through a cascade system consisting of a series of seven earth-walled lagoons built on terraces on the slopes of the colliery's waste heap. OR 75-5

MD75-10 ULTRASONIC ASSIST IN FILTERING NEUTRALIZED MINE WATER SLURRY

Fairbanks, H. V. and Hacket, W. L., W. Va. Univ., Coal Res. Bur., Tech. Rept. No. 117, Oct. 1975. 13 pp. The influence of ultrasonic radiation on the filtration rate and filtering efficiency of neutralized acid mine drainage slurry was studied. Test runs were made at various pressure drops and ultrasonic intensities. Results showed that ultrasound substantially increased both filtration rate and filtering efficiency, and also appeared to increase coagulation of gelatinous particles. OR 75-25

MD75-11 COAL MINING, WATER AND THE ENVIRONMENT

Glover, G., National Coal Board, Yorkshire, England, Sept. 1975. 18 pp. This general discussion of water in coal mining operations includes consideration of inflow from ground, surface and use of public supplies; contamination of drainage and surface water; waste water treatment; restrictions on drainage; and monitoring the quality of discharges. Data on analyses of various waters are tabulated. OR 75-6

MD75-12 STREAM REHABILITATION THROUGH CONTROL OF NON-POINT SOURCES OF ACID MINE DRAINAGE

Herricks, E. E. (1) and Cairns, J., Jr. (2) [(1) Union Carbide Corp. (2) VPI & SU], Proc. Non-Point Sources Water Pollut., Southeastern Reg. Conf., by Va. Water Resour. Res. Cent., Blacksburg, Va., May 1,2, 1975. pp 239-256. Much of the study showing the impact of acid mine drainage on Indian Creek, Pennsylvania is presented. Methods of controlling polluted drainage from steep slope and area mining operations and from coal processing plants are illustrated. "Biotic preserves" are suggested as a source of organisms to recolonize damaged areas. OR 75-45

MD75-13 HYDROLOGIC AND WATER QUALITY MODELING OF SURFACE WATER DISCHARGES FROM MINING OPERATIONS

Herricks, E. E., Shanholtz, V. O., and Contractor, D. N., Va. Polytech. Inst. and State Univ., Dept. Agr. Eng., Res. Div. Rept. 159, Jan. 1975. 44 pp. This report summarizes an inter-disciplinary effort directed toward evaluating the feasibility of mathematically modeling the hydrologic and related water quality problems associated with surface mining activities. The overall objective was to explore possible methods of providing a more reliable, efficient and effective tool to evaluate potential environmental hazards from a given surface mining strategy. Studies discussed include generating synthetic daily stream flow data for ungaged watersheds; developing a model to predict SO_4 concentrations in the stream system; determining particles on stream bed that can be moved as a function of stream discharge; and developing a finite element overland flow model. (From Introduction) OR 75-10

MD75-14 MODELS TO PREDICT ENVIRONMENTAL IMPACT OF MINE DRAINAGE ON STREAMS

Herricks, E. E. (1), Shanholtz, V. O. (2), Contractor, D. N. (2) [(1) Union Carbide Corp., Tarrytown, N. Y. (2) VPI & SU], Trans. ASAE 18 (4), 657-663, 667 (1975). The Stanford Watershed Model was calibrated on the Poplar Run sub-basin of Indian Creek, Pennsylvania for generation of stream-flow data. The main difficulty in using the calibrated model for generating flows in other parts of Indian Creek Basin was the lack of necessary hourly precipitation data. Also, the model did not take into account snow melt. Data from the model were used to investigate sulfate concentrations and sediment movement and thus evaluate the impact of mine drainage on the watershed. OR 75-27

MD75-15 NON-POINT POLLUTION FROM MINING AND MINERAL EXTRACTION

Hill, R. D. (Mining Pollution Control Branch, U.S. EPA), Proc. Conf. Non-Point Sources Water Pollution, Blacksburg, Va., by Va. Water Resour. Res. Cent., 1975. pp 67-81. This review of mining and its related problems emphasizes acid mine drainage abatement and control from abandoned mines and from surface mining;

MD75-15 (continued)

control of erosion and sedimentation from surface mining; and reclamation of surface mines especially in regard to quality of drainage from mined and reclaimed areas. OR 75-14

MD75-16 SEDIMENT CONTROL AND SURFACE MINING

Hill, R. D. (U.S. EPA, Mining Pollut. Contr. Br., Cincinnati, Ohio), Proc. Polish-U.S. Symp. Environ. Protection in Openpit Coal Mining, by U.S. EPA and Cent. Res. Design Inst. Opencast Mining, Poland (POLTEGOR), Denver, Colo., May 27-29, 1975. Publ. by Univ. Denver Res. Inst., Sept. 1975. pp 89-95. NTIS, PB-249 300. This review of sediment control discusses the influence of topography, mining methods that minimize erosion, the use of mulches and revegetation, and the design of sediment ponds. OR 75-34

MD75-17 PURIFICATION OF WATERS FROM STRIP LIGNITE MINES

Janiak, H. (POLTEGOR), Proc. Polish-U.S. Symp. Environ. Protection in Openpit Coal Mining, by U.S. EPA and Cent. Res. Design Inst. Opencast Mining, Poland (POLTEGOR), Denver, Colo., May 27-29, 1975. Publ. by Univ. Denver Res. Inst., Sept. 1975. pp 59-68. NTIS, PB-249 300. This is a summary of the work reported elsewhere. OR 75-32

MD75-18 PURIFICATION OF WATERS FROM STRIP LIGNITE MINES

Janiak, H., et al., Central Res. Design Inst. Opencast Mining, POLTEGOR (Poland), 1st Interim Rept. to U.S. EPA, Special Foreign Currency Program Project 05-534-3, July 1975. 131 pp.+ Since an important pollution problem of waters from lignite mines in Poland is suspended solids, laboratory studies were carried out on three mine waters to test the effectiveness of 17 flocculents, 13 produced in the United States and 4 in Poland. Best results were obtained with cationic polyelectrolytes. The effect of radiation on settling was also studied in the laboratory and seemed to vary with the source of the water and change in pH. The plan of field work is described. An actual mine drainage will be tested with the successful flocculents used in the laboratory studies. The construction of the experimental settling basin for the field work has already begun and is pictured. OR 75-15

MD75-19 HYDROGEOLOGICAL ASPECTS OF ENVIRONMENTAL PROTECTION IN POLISH OPENPIT MINING

Libicki, J. (POLTEGOR), Proc. Polish-U.S. Symp. Environ. Protection in Openpit Coal Mining, by U.S. EPA and Cent. Res. Design Inst. Opencast Mining, Poland (POLTEGOR), Denver, Colo., May 27-29, 1975. Publ. by Univ. Denver Res. Inst., Sept. 1975. pp 37-45. NTIS, PB-249 300. Two types of problems resulting from surface mining of coal below the natural ground water level are outlined. When ground water is pumped out of an area to keep the pits dry, subsidence can result and vegetation depending on subsurface water can be affected. Also, if strip pits are used for coal refuse and ash disposal there may be effects on the quality of the ground water. OR 75-30

MD75-20 DENTS RUN WATERSHED PROJECT

Light, B. A. (Consolidation Coal Co., Christopher Coal Co. Div.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Third Symp. Surface Mining and Reclamation Preprints, Vol. 1, Louisville, Ky. (1975). pp 148-151. Consol's part in the cooperative project to clean up the watershed, located in northern West Virginia, was concentrated on treating six discharges from the Osage Mine. The two treatment plants built for combined discharges are described. Typical analyses of drainage and treated water show the success of the treatment plants in meeting water quality standards. OR 75-38

MD75-21 THE EFFECTS OF MODERN STRIP MINING ON WATER RESOURCES

Light, E., Campaign Clean Water, Charleston, W. Va., March 1975. 18 pp. Information from 51 references is used in this discussion of sedimentation, water quality, and changes in hydrology resulting from surface mining. OR 75-1

MD75-22 REFUSE BANK RUN-OFF, ITS CHARACTERISTICS AND DISPOSAL

Maneval, D. R. (Appalachian Regional Comm.), Proc. Polish-U.S. Symp. Environ. Protection in Openpit Coal Mining, by U.S. EPA and Cent. Res. Design Inst. Opencast Mining, Poland (POLTEGOR), Denver, Colo., May 27-29, 1975. Publ. by Univ. Denver Res. Inst., Sept. 1975. pp 69-78. NTIS, PB-249 300. Control of drainage from coal refuse and methods of treating acid drainage from refuse and water from coal cleaning plants are described. OR 75-33

MD75-23 POTOMAC RIVER BASIN WATER QUALITY STATUS AND TREND ASSESSMENT 1962-1973

Mason, W. T., Jr., Palmer, R. N., Sheer, D. P., and Combs, B. J., Interstate Comm. Potomac River Basin, IC PRB Tech. Publ. 75-3, March 1975. 161 pp. Bacteriological, chemical, and physical parameters at 37 stations throughout the Potomac River Basin are recorded. Acid mine drainage is indicated as the predominant pollutant in the North Branch and headwater tributaries. OR 75-4

MD75-24 SULFUR OCCURRENCE IN COAL AND ITS RELATIONSHIP TO ACID WATER FORMATION: LITERATURE REVIEW

McMillan, B. G., W. Va. Univ., Coal Res. Bur., Tech. Rept. No. 110, Undated. 18 pp. The bibliography lists 24 references which are the basis for discussion of the contribution of various forms of sulfur, elemental, organic, pyritic, and sulfates, to mine water pollution. The literature indicates that framboidal pyrite is a major source of acid mine drainage. OR 75-24

MD75-25 WATER QUALITY CONTROL IN MINE SPOILS: UPPER COLORADO RIVER BASIN

McWhorter, D. B., Skogerboe, R. K., and Skogerboe, G. V. (Colo. State Univ.), U.S. EPA Environ. Protection Technol. Ser. EPA-670/2-75-048 (June 1975). 99 pp. NTIS, PB-242 908/AS. This study was made to identify water quality problems resulting from runoff and water percolation thru mine spoils in the Upper Colorado River Basin. Significant soluble salts were monitored entering receiving waters. No heavy metal salts were found in coal mine spoils studied but metal mine refuse did produce heavy metal salts. A method of estimating future salt production was developed. OR 75-7

MD75-26 UP-DIP VERSUS DOWN-DIP MINING: AN EVALUATION

Mentz, J. W. and Warg, J. B. (Skelly and Loy, Engineers-Consultants), U.S. EPA Environ. Protection Technol. Ser. EPA-670/2-75-047 (June 1975). 74 pp. NTIS, PB-244 420/6WP. The report presents detailed results of a feasibility study of down-dip mining, a technique that appears to offer an alternative to sealing or permanent treatment of polluted effluents from coal mines after abandonment. The project included an evaluation of a pair of nearly identical abandoned underground mines in Clearfield County, Pennsylvania - one developed to rise, one developed to dip - to confirm the theory that discharge water quality in down-dip mines is substantially better than that in up-dip mines. A nearby active mine with units operating up-dip and down-dip was also evaluated to ascertain economic and engineering limitations, costs in varying situations, and other major disadvantages or disadvantages of each mode of operation. Health and safety, national water quality, and economic impacts resulting from widespread use versus non-use of the technique were also assessed. (Authors' abstract modified) OR 75-8

MD75-27 SEDIMENT CONTROL DURING MINING AND MINE RECLAMATION

Nawrocki, M. A. (Hittman Assoc., Inc.), Proc. Non-Point Sources Water Pollut., Southeastern Reg. Conf., by Va. Water Resour. Res. Cent., Blacksburg, Va., May 1, 2, 1975. pp 257-266. Sediment control problems related to surface mining are discussed. Erosion is reduced by controlling runoff, minimizing area exposed, and soil stabilization. Sediment can be contained by traps, stoney filtering areas, and vegetated buffer zones and by diversion of drainage into detention ponds. OR 75-46

MD75-28 EVALUATION OF SEDIMENTATION PONDS USED IN SURFACE COAL MINING

Nawrocki, M. A. and Vir Kathuria, D. (Hittman Associates, Inc.), Natl. Coal Assoc./ Bitum. Coal Res., Inc., Third Symp. Surface Mining and Reclamation Preprints, Vol. 2, Louisville, Ky. (1975). pp 42-47. In this project the objective was to determine the overall effectiveness of sedimentation ponds in removing suspended solids. Nine ponds in Kentucky, Pennsylvania, and West Virginia were selected for the program. Field sampling was done to learn efficiencies of removal in runoff flows. Water quality measurements and flow rates were recorded at both the influent to and the effluent from the ponds. Characteristics of the ponds are listed and individual descriptions are also given. The ponds had a wide range of suspended solids removal efficiencies during rainfall conditions. Results indicated that the efficiency of dugout type ponds built off the natural waterway is greater than that of ponds built across the natural waterway. OR 75-39

MD75-29 TREATMENT OF COAL MINE DRAINAGE WITH THE ROTATING BIOLOGICAL CONTACTOR

Olem, H. and Unz, R. F. (Pa. State Univ., Dept. Civil Eng.), 30th Ann. Purdue Ind. Waste Conf., 1975. 40 pp. Discharge from abandoned Proctor No. 2 mine at the Hollywood, Pennsylvania, Experimental Mine Drainage Treatment Facility was provided to two RBC units. One unit was run continuously from May 1974 through March 1975 to study ferrous iron oxidation with varied disc rotation rates and hydraulic loadings. The other unit was operated at constant disc rotation rate from August 1974 through March 1975 to study solids formation and the microbiology of the process. Since results show that the apparatus effectively oxidized ferrous iron in unmodified acid mine drainage, it is concluded that the RBC has potential application as a first step in a mine drainage treatment process. OR 75-12

MD75-30 RELATIONSHIP OF GROUND-WATER MOVEMENT AND STRIP MINE RECLAMATION

Pennington, D. (John McCormick and Associates, Devon, Pa.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Third Symp. Surface Mining and Reclamation Preprints, Vol. 1, Louisville, Ky. (1975). pp 170-178. This paper describes the surface conditions and the underground water conditions in the Mahanoy Creek watershed of eastern Pennsylvania. Since water enters the drainage system from outside the watershed and moves miles through a series of more than thirteen interconnected underground mine pools, surface mine reclamation in the area has not significantly reduced mine drainage. The reduction of discharges brought about by surface reclamation and the costs of the improvements are tabulated. OR 75-40

MD75-31 CHANGES IN WATER CHEMISTRY RESULTING FROM SURFACE-MINING OF COAL ON FOUR WEST VIRGINIA WATERSHEDS

Plass, W. T. (Northeastern Forest Expt. Sta., Princeton, W. Va.), Natl. Coal Assoc./ Bitum. Coal Res., Inc., Third Symp. Surface Mining and Reclamation Preprints, Vol. 1, Louisville, Ky. (1975). pp 152-169. Also in Green Lands 6 (1), 22-27 (Winter 1976). Water quality in contiguous watersheds was monitored from May 1969 through April 1974 in order to provide much needed information on normal variations in water quality so that valid comparisons of water quality before and after mining can be made. Sampling was done every two weeks and analyses were made for pH, specific conductance, alkalinity, sulfate, calcium, bicarbonate, magnesium, iron, aluminum, manganese, zinc, and potassium. Results of analyses were evaluated for before-mining

MD75-31 (continued)

variations between samples taken in growing and dormant seasons and for water years 1970, 1971, and 1972 which cover a wide range of precipitation. Also, each factor for which analyses were made is discussed and the effect on the parameter of mining in the various watersheds is evaluated. OR 75-41

MD75-32 WATER QUALITY MODELS FOR A CONTOUR MINED WATERSHED

Plass, W. T. (1), Connell, J. F. (2), Contractor, D. N. (2), and Shanholtz, V. O. (2) [(1) Northeastern Forest Expt. Sta., Princeton, W. Va., (2) VPI and SU], Natl. Coal Assoc./Bitum. Coal Res. Inc., Third Symp. Surface Mining and Reclamation Preprints, Vol. 1, Louisville, Ky. (1975). pp 179-199. The production of sulfate and other chemicals at a strip mine and their transport to local streams is a complex process that involves the kinetics of the chemical reactions and the hydrology and geology of the area. This study attempts to understand the interactions involved and to relate various water quality parameters to the hydrology of the area. Data was furnished by the Northeastern Forest Experiment Station, Princeton, W. Va. from the Stover B watershed which they had monitored. (From Introduction) OR 75-42

MD75-33 QUICK-CONNECT PIPE CUTS INSTALLATION COSTS AT BARNES & TUCKER MINES

Coal Age 80 (7), 102-104 (1975). In this description of the use of filament-wound fiberglass/epoxy pipe for water handling systems, the pipe's capability of carrying acid mine drainage water to the surface at line pressures of more than 300 psi is noted. It is also mentioned that yellow boy can be cleaned out of the pipe by forcing a special polyurethane-covered foam cylinder through the line. OR 75-3

MD75-34 RELATIONSHIP BETWEEN UNDERGROUND MINE WATER POOLS AND SUBSIDENCE IN THE NORTHEASTERN PENNSYLVANIA ANTHRACITE FIELDS

A. W. Martin Associates, Inc., Rept. to Pa. Dept. Environ. Resour., and Appalachian Regional Comm., ARC-73-111-2553 (1975). 130 pp. and Appendixes A through D. This study analyzes the relationship between the effects of mine pools on underground mine voids and subsidence in the Northeastern Anthracite Coal Fields of Pennsylvania. Some 29 mineable coal seams exist in this area. Data assembled include time and locations of subsidences, precipitation records, mine pool elevation, dates of mine closure, and subsurface information. Appropriate control measures recommended include variations of flushing methods which have been most successful, and the use of pressure-relief boreholes. (Adapted from Executive Summary) OR 75-17

MD75-35 CRITERIA FOR DEVELOPING POLLUTION ABATEMENT PROGRAMS FOR INACTIVE AND ABANDONED MINE SITE

Robins, J. D. and Hutchins, J. C., Skelly and Loy, Engineers-Consultants, Rept. to U.S. EPA, Office Water Hazardous Materials, EPA-440/9-75-008, 1975. (510 pp.) Both surface and underground coal mines are considered in this report. Discussion includes environmental impacts of mining and effects of reclamation; sources of financial and technical aid; and legal problems. The Appendix summarizes programs in Illinois, Maryland, Pennsylvania, Virginia, Kentucky, and Ohio for reclamation of abandoned mined lands. OR 75-29

MD75-36 REMOVAL OF MANGANESE FROM MINE DRAINAGE BY OZONE AND CHLORINE

Rozelle, R. B. and Swain, H. A., Jr. (Wilkes College), U.S. EPA Environ. Protection Technol. Series EPA 670/2-75-006 (1975). 47 pp. NTIS, PB-241 143. Laboratory studies showed that treatment of synthetic mine drainage with ozone or with hypochlorite ion reduced manganese concentration to less than 1 mg per liter. Laboratory methods and results including solubility and kinetic studies are reported. Cost estimates of both treatment methods are presented. OR 75-9

MD75-37 INACTIVE AND ABANDONED UNDERGROUND MINES - WATER POLLUTION PREVENTION & CONTROL

Scott, R. L. and Hays, R. M., Michael Baker, Jr., Inc., Rept. to U.S. EPA Office Water Hazardous Materials, EPA-440/9-75-007 (1975). 338 pp. This report discusses in Part I the chemistry and geographic extent of mine drainage pollution in the United States from inactive and abandoned underground mines; underground mining methods; and the classification of mine drainage control techniques. Available at-source mine drainage pollution prevention and control techniques are described and evaluated in Part II of the report and consist of five major categories: (1) Water Infiltration Control; (2) Mine Sealing; (3) Mining Techniques; (4) Water Handling; and (5) Discharge Quality Control. Actual cases illustrate the use of techniques and include cost data. OR 75-16

MD75-38 INFLUENCE OF WATER QUALITY ON THE CORROSION AND ELECTROCHEMICAL BEHAVIOR OF MILD STEEL IN SYNTHETIC ACID MINE WATERS

Subrahmanyam, D. V. and Hoey, G. R. (Dept. Energy, Mines, Resour., Ottawa, Canada), Corrosion 31 (6), 202-207 (1975). Mild steel panels which had been carefully cleaned were exposed to synthetic acid mine waters containing Fe^{+3}, Fe^{+2}, Cu^{+2}, Mg^{+2}, Ca^{+2}, K^{+}, SO_4^{-2}, Cl^{-}, and SO_3^{-2} in various combinations. Ferric and cupric ion content and, in some cases, sulfite, increased the corrosion rate of the steel. Where no copper is present, corrosion rate is directly proportional to the ferric ion reduction rate. Although polarizing the steel will reduce the corrosion rates significantly in solutions containing ferric ions, the current density required makes the feasibility of cathodic protection doubtful under these conditions. OR 75-19

MD75-39 SOME OBSERVATIONS ON SPAWNING OF BROOK TROUT IN LIME NEUTRALIZED IRON HYDROXIDE SUSPENSIONS

Sykora, J. L., Smith, E. J., Synak, M., and Shapiro, M. A. (Univ. Pittsburgh, Grad. School Public Health), Water Res. 9 (4), 451-458 (1975). The long-term effect of lime neutralized suspended iron on brook trout spawning and egg hatchability was assessed in a flow-through environment with a modified proportional diluter. Results of a two year study reveal low survival of maturing fish and a decline in egg production at higher suspended iron concentrations. Brook trout egg hatchability was unaffected in concentrations of lime neutralized iron hydroxide ranging from 0.75 to 12 mg Fe per liter. A comparison of data on survival, growth, and egg hatchability indicates that the safe level of lime neutralized iron hydroxide suspensions for brook trout in an enclosed, intermittent-flow testing system presumably lies between 7.5 and 12.5 mg Fe per liter. (Authors' abstract) OR 75-11

MD75-40 HYDROLOGY OF BLACK MESA RECLAIMED LAND

Thames, J. L., Patten, R. T., and Crompton, E. J. (Univ. Ariz., Dept. Watershed Management), Mining Congr. J. 61 (7), 16-20 (1975). A study by Peabody Coal Co. and the University of Arizona is being made on two watersheds, one on reclaimed land and one on an undisturbed 5-acre area. Both have been instrumented to measure a number of hydrologic variables including precipitation, amount and quality of runoff, and spoil permeability. OR 75-43

MD75-41 TOLERANCE AND SYNTHETIC ABILITY OF SEWAGE MICROORGANISMS IN ACID MINE WATER

Thompson, F. C. and Wilson, H. A., W. Va. Univ., Water Res. Inst., Bull. 5, 1975. 60 pp. This paper describes laboratory work using synthetic mine waters of various pH values and iron content to study two selected microorganisms and their ability to utilize sewage nutrients. The results showed that bacteria in acid mine waters contribute little cleansing action and under extreme acid conditons no bacteria were present. OR 75-22

MD75-42 GEOHYDROLOGIC RECONNAISANCE OF THE UPPER POTOMAC RIVER BASIN

Trainer, F. W. and Watkins, F. A., Jr., U.S. Geol. Surv., Water-Supply Paper 2035, 1975. 68 pp.+ Geologic conditions in the basin and their effect on water quality are described. A short section is included on acid mine drainage and its contribution to the water problems of the North Branch Potomac River. OR 75-23

MD75-43 USE OF PHOTO INTERPRETATION AND GEOLOGICAL DATA IN THE IDENTIFICATION OF SURFACE DAMAGE AND SUBSIDENCE

Earth Satellite Corporation, Final Rept. to Appalachian Regional Comm., ARC-73-111-2554, 1975. 104 pp.+ This survey of the Northern Anthracite Coal Field shows that remote sensing techniques can also be used to determine sources and movement of acid mine water and sources of surface infiltration into mined out areas. OR 75-35

MD75-44 HYDROLOGIC RESEARCH IN STRIP-MINED AREAS OF SOUTHEASTERN MONTANA

Van Voast, W. A. (1,2), Hedges, R. B. (2), and Pagenkopf, G. K. (3) [(1) Mont. College Miner. Sci. Technol. (2) Mont. Bur. Miner. Geol. (3) Mont. State Univ.], Proc. Polish-U.S. Symp. Environ. Protection in Openpit Coal Mining, by U.S. EPA and Cent. Res. Design Inst. Opencast Mining, Poland (POLTEGOR), Denver, Colo., May 27-29, 1975. Publ. by Univ. Denver Res. Inst., Sept. 1975. pp 47-57. NTIS, PB-249 300. The plan of study of the Birney-Decker area, some observations of effects of mining on water quality and hydrology, and some preliminary results of laboratory simulation are reviewed. OR 75-31

MD75-45 MINE DRAINAGE POLLUTION REDUCTION BY INHIBITION OF IRON BACTERIA

Walsh, F. and Mitchell, R. (Harvard Univ., Lab. Applied Microbiol.), Water Res. 9, 525-528 (1975). In the laboratory, synthetic acid ground waters with three levels of iron concentration were directed through coal shale columns, some innoculated with *Thiobacillus ferrooxidans* and *Metallogenium*. With high iron influent, the rate of total iron and acidity release from the coal shale was reduced. Results also indicate the possibility that bacterial activity is inhibited. OR 75-28

MD75-46 HYDRA-SLUDGE REMOVAL SYSTEM FOR MINE DRAINAGE AND COAL PREPARATION PLANT SLUDGE

Werner, R. H. (Barrett Haentjens and Co. of Pittsburgh), AIME Ann. Meet. New York, N. Y., 1975. Preprint No. 75F83. 13 pp. An automatically controlled commercial pumping system, which will hydraulically remove sludge materials from a settling pond or thickener, is described. OR 75-13

1976

MD76-1 COAL PILE LEACHATE QUANTITY AND QUALITY CHARACTERISTICS

Anderson, W. C. and Youngstrom, M. P. (Pickard and Anderson), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 17 pp. A coal storage pile at Cornell University heating plant was monitored for quality and quantity of leachate in order to design treatment facilities for the runoff. The quantity depends on the topography and drainage area of the coal pile site, configuration of the pile, and the volume, type and intensity of precipitation. The quality depends upon the foregoing and the coal type, quality and particle size, and the reaction time, which is the time between precipitation incidents when retained moisture in the pile is dissolving minerals. The dissolved contaminants are flushed out at the beginning of a precipitation event, and continuing precipitation produces lower fairly constant levels of dissolved materials. A method is presented to characterize the leachate quality and quantity for any desired design precipitation condition. OR 76-4

MD76-2 HOT SURFACTANT SOLUTION AS A DEWATERING AID DURING FILTRATION

Baker, A. F. (U.S. Bur. Mines), Natl. Coal Assoc./Bitum. Coal Res., Inc., Second Symp. Preparation, Louisville, Ky. (1976). 9 pp. Laboratory studies are being carried out on the use of surfactant solution to improve the dewatering of fine coal by vacuum filtration. The best moisture reduction was obtained by washing the filter cake with hot surfactant solution, then heating with steam. OR 76-23

MD76-3 FEASIBILITY OF USING REVERSE OSMOSIS TO TREAT ACID MINE WATERS

Blackshaw, G. L., Pappano, A. W., Thomas, G. E., Jr., and Cheng, S. Y. (W. Va. Univ., Dept. Chem. Eng.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 18 pp. A discussion of the general use and theory of reverse osmosis, its application to acid mine drainage treatment, and the experience with RO at EPA's Crown Mine Drainage Field Site introduces the report of the development and experimental studies of a combined treatment process. The ion exchange-reverse osmosis (IX-RO) treatment was used with acid mine drainage having significant amounts of ferrous iron. The feed to the ion exchange unit is acidified to prevent iron fouling of the resin. The IX effluent, essentially calcium-free, is demineralized in its RO unit. The regeneration of the IX resin can include the use of the RO concentrate. OR 76-9

MD76-4 EVALUATION OF THE ENVIRONMENTAL EFFECTIVENESS OF CLOSE DOWN PROCEDURES - EASTERN UNDERGROUND COAL MINES

Bucek, M. F., Emel, J. L., Petrus, C. A., and Schad, J. A. (HRB - Singer Inc.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 5 pp. This paper summarizes the results of a study that attempted to assess the effectiveness of the closures, mainly sealing methods, implemented in a large geographic area. Criteria that were developed related to the effect on mine effluent quality and quantity. (From authors' Introduction) OR 76-20

MD76-5 CHARACTER OF DRAINAGE AS A FUNCTION OF THE OCCURRENCE OF FRAMBOIDAL PYRITE AND GROUND WATER QUALITY IN EASTERN KENTUCKY

Caruccio, F. T., Geidel, G., and Sewell, J. M. (Univ. S. C.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 16 pp. In a field study, the paleoenvironments of a number of coal seams were identified and the distribution of framboidal pyrite was determined. Framboidal (reactive) pyrite occurred fairly widely, but seemed to be more abundant in coal seams of marine-brackish water paleoenvironment. In the study area, strata producing acidic drainage had most of the pyrite in the framboidal form and low buffering capacity in the water. Strata producing low to high sulfate-neutral drainages usually had a much lower amount of pyrite in the framboidal form and were associated with highly buffered alkaline-water systems. OR 76-3

MD76-6 WATER QUALITY RELATIONSHIPS AS A FUNCTION OF ACID MINE DRAINAGE INPUTS INTO THE SUSQUEHANNA RIVER

Cline, J. T. (1) and Balla, R. (2) [(1) Wilkes College (2) Luzerne County Conserv. Dist.], Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 15 pp. Physical, chemical and biological data collected in 1973 in a section of the North Branch of the river were correlated by a factor analysis program. The area studied received sewage and industrial pollution as well as mine drainage. Acid and iron components of mine drainage were determined to be most detrimental to biota although the river appeared to recover from mine drainage effects within a short distance downstream. OR 76-5

MD76-7 COAL, NPDES, AND YOU

Cloward, W. H. (U.S. EPA, Atlanta, Georgia), Natl. Coal Assoc./Bitum. Coal Res.,

MD76-7 (continued)

Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 2 pp. The definitions of "existing" and "new" pollutant sources and requirements for permits for each under the National Pollutant Discharge Elimination System are discussed. OR 76-14

MD76-8 COMPACT LAMELLA THICKENERS IN COAL PREPARATION PLANTS

Cook, R. L. (Parkson Corp.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Second Symp. Preparation, Louisville, Ky. (1976). 10 pp. The theory, design, and development of the Lamella Thickener, an inclined shallow depth sedimentation device, is described. Operation and results at full scale preparation plants are presented. OR 76-21

MD76-9 UTILIZATION OF WASH WATER SLUDGE

Crossmore, E. Y. (Crossmore and Miller), Natl. Coal /Bitum. Coal Res., Inc., Second Symp. Preparation, Louisville, Ky. (1976). 10 pp. Sludge is made into briquettes with drying and then with addition of rock salt (sodium chloride) as binder. Temperature and pressure are controlled so that the binder produces dendritic crystals, resulting in a product which is impervious to moisture. OR 76-22

MD76-10 NATURAL BENEFICIATION OF ACID MINE DRAINAGE BY INTERACTION OF STREAM WATER WITH STREAM SEDIMENT

Crouse, H. L. (1), and Rose, A. W. (2) [(1) D'Appolonia Consulting Engineers, Inc., (2) Pa. State Univ., Dept. Geosci.], Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 33 pp. Babb Creek in Tioga County, Pennsylvania, the stream investigated, runs through sparsely-populated heavily-forested land. Its main pollutants are drainage from surface mining and coal refuse piles. Natural beneficiation was determined to be the result of dilution; neutralization by natural alkalinity, and interaction with stream sediments. Iron concentration in the stream appears to be controlled by the solubility of ferric oxyhydroxides. Aluminum concentration appears to be controlled by kaolinite in alkaline and slightly acid water and by gibbsite in more acid water. OR 76-18

MD76-11 AN INTERGOVERNMENTAL PROJECT TO IMPROVE ENVIRONMENTAL QUALITY IN AN AREA OF ABANDONED MINES

Davis, R. S. (1) and Maneval, D. R. (2) [(1) U.S. EPA Phila., Pa., (2) Appalachian Regional Comm.], Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 16 pp. An abatement program has been developed for Settler's Cabin Park near Pittsburgh. A number of sources of acid mine drainage from unreclaimed surface mines and an abandoned deep mine pollute Pinkerton's Run which goes through the park. A cost summary and projected water improvements are presented. OR 76-13

MD76-12 EFFECTS OF COAL STRIP MINING ON STREAM WATER QUALITY: PRELIMINARY RESULTS

Dettmann, E. H., Olsen, R. D., and Vinikour, W. S. (Argonne National Laboratory), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 17 pp. A study is being carried out on the Tongue River in the Powder River Basin in Wyoming and Montana. Samples from upstream and downstream of the Big Horn Mine and from the mine discharges were analyzed for a number of components. Results suggest that impacts of mining on water quality may be relatively small and that biota respond to overall water quality trends rather than impacts from mining. OR 76-6

MD76-13 HYDROLOGIC AND SOIL PROPERTIES OF COAL MINE OVERBURDEN PILES IN SOUTHEASTERN MONTANA

Farmer, E. E. and Richardson, B. Z. (Intermountain Forest and Range Expt. Sta., U.S. Dept. Agr.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Fourth Symp. Surface Mining and Reclamation, Louisville, Ky. (1976). 11 pp. This paper reports the results of research conducted in 1973 and 1974 on the infiltration and erosion rates of bare overburden piles and examines the influence of several soil variables on these hydrologic characteristics. The work was done at the Decker Mine. (From authors' Introduction) OR 76-24

MD76-14 DISPOSAL OF SLUDGE FROM ACID MINE DRAINAGE NEUTRALIZATION

Grube, W. E., Jr. and Wilmoth, R. C. (Crown Mine Drainage Control Field Site, U.S. EPA), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 20 pp. In a spray-irrigation study, sludge was applied to mine refuse materials. Comparison of the test plot with a control and an area that received a comparable quantity of tap water showed that sludge might have a slight beneficial effect on vegetative growth and that while sludge did not erode much during light precipitation, erosion was a problem during heavier rainfall. A drying bed study was carried out both in cold and warm weather. The problems caused by freezing are discussed. In warm weather, lime-neutralized, coagulant-treated sludge appeared to stabilize at 20 percent solids within 20 days drying time. Drainage rate and effluent quality were monitored. OR 76-11

MD76-15 SEDIMENTATION PONDS - A CRITICAL REVIEW

Hill, R. D. (EPA, Ind. Environ. Res. Lab., Cincinnati, O.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 10 pp. Design factors and maintenance of sedimentation ponds are evaluated for their effects on the deposit and retention of suspended solids. OR 76-15

MD76-16 CUSTOM DESIGNED SURFACE MANIPULATION AND SEEDING EQUIPMENT FOR EROSION CONTROL AND VEGETATION ESTABLISHMENT

Jensen, I. B. and Hodder, R. L. (Mt. Agr. Expt. Sta.), Natl. Coal Assoc./Bitum. Coal Res., Inc.,Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 12 pp. The earth moving machinery described was developed to prepare soil banks and land to be reclaimed so that rainfall would not be lost as runoff. Equipment developed as gougers make shallow elongated depressions on gentle slopes. Dozer basins are depressions formed on steep slopes by a specially designed blade which excavates and roughens the uphill surface and compacts the soil deposited on the down slope. The use of the diesel plow to break up compacted soils and the development of an improved broadcast seeder are also described. OR 76-16

MD76-17 POTENTIAL APPLICATION OF VEGETATIVE FILTER FOR MINE DRAINAGE SEDIMENT CONTROL

Kao, D. T. Y. (1), Lyons, A. E., Jr. (2), and Barfield, B. J. (1) [(1) Univ. Ky. (2) AMINOIL, U.S.A.], Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 12 pp. In this laboratory study, plastic "grasses" of three levels of flexibility were prepared to simulate vegetation and glass beads sized from 0.001 to 0.025 inches simulated sediment. Water and sediment were sent over the artificial grasses on the floor of a 16 foot flume. A high trapping efficiency was observed. OR 76-17

MD76-18 AT-SOURCE CONTROL THROUGH THE APPLICATION OF SEVERAL ABATEMENT TECHNIQUES

Klingensmith, R. S., Miorin, A. F., and Saliunas, J. R. (Gannett Fleming Corddry and Carpenter, Inc.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 15 pp. The various abatement

MD76-18 (continued)

techniques used at Catawissa Creek Project, Beech Creek and Little Sandy Run Project and Tioga River Project are described. They include reconstructing stream beds, daylighting, sealing deep mine workings, and reclaiming surface mined areas. The application of at-source controls as part of the surface mine operation is also described. OR 76-19

MD76-19 EFFLUENT GUIDELINES: GOVERNMENT AND INDUSTRY OR GOVERNMENT VERSUS INDUSTRY???

Loy, L. D., Jr. (Skelly and Loy, Engineers, Consultants), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 4 pp. The cooperative program between the coal industry, represented by NCA, and EPA to establish the effluent guidelines is described as an example of how input from industry during the development of guidelines can lead to realistic environmental regulations. OR 76-12

MD76-20 EROSION AND SEDIMENT CONTROL DURING SURFACE MINING IN THE EASTERN UNITED STATES

Mills, T. R. and Clar, M. L. (Hittman Associates, Inc.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 14 pp. The manual of practice for formulating and implementing erosion control plans, prepared by the company for EPA, is summarized. OR 76-26

MD76-21 ALUMINA-LIME-SODA PROCESS PARAMETERS FOR RECOVERING POTABLE WATER FROM ACID MINE DRAINAGE

Nebgen, J. W., Weatherman, D. F., Valentine, M., and Shea, E. P. (Midwest Research Institute), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 14 pp. The process has been field tested at the Hollywood, Pennsylvania, Experimental Mine Drainage Treatment Facility. In the first process stage, raw water is treated with sodium aluminate and lime to precipitate a calcium sulfoaluminate sludge. In stage II the alkaline effluent of stage I is blended with raw water, the amount predetermined to give a desired sulfate level in the product, and then is neutralized by carbon dioxide addition to a pH 10.3 where calcium carbonate is least soluble. Solids removed at this step also include metal hydroxides. The emphasis of this paper is on stage I and the following topics are discussed: sensitivity of sulfate removal to pH; iron and aluminum residuals; lime requirements of reaction product solids; dewatering characteristics of solids. Process economics for three different size plants and the effect of drainage compositions on chemical costs are summarized. OR 76-8

MD76-22 MICROBIAL OXIDATION OF FERROUS IRON IN COAL MINE DRAINAGE TREATMENT

Olem, H. and Unz, R. F. (Pa. State Univ., Dept. Civil Eng.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 17 pp. The application of the rotating biological contactor to mine drainage treatment is described. It required no bacterial preseeding or nutrient supplement. The feed water used was from the Proctor No. 2 discharge at the Hollywood, Pennsylvania, Experimental Mine Drainage Treatment Facility and had a ferrous iron concentration that ranged from 16-313 mg/l. Tests were run on one unit to evaluate oxidation at varied disc rotation rates and hydraulic loadings. A second unit was operated at a constant rate for 8 months for studies on solids formation and microbiology. OR 76-10

MD76-23 HYDROLOGIC ASPECTS OF STRIP MINING IN THE SUBBITUMINOUS COAL FIELDS OF MONTANA

Van Voast, W. A., Hedges, R. B., and McDermott, J. J. (Mt. Bur. Mines Geol.), Natl. Coal Assoc./Bitum. Coal Res., Inc., Fourth Symp. Surface Mining and Reclamation,

MD76-23 (continued)

Louisville, Ky. (1976). 13 pp. Effects of surface mining on the quality and availability of water are discussed. Mainly local impacts particularly on water quality are expected. Since many aquifers presently used are in the coal seams, aquifers below levels disturbed by mining are suggested as alternate water sources. OR 76-25

MD76-24 COMBINATION LIMESTONE-LIME TREATMENT OF ACID MINE DRAINAGE

Wilmoth, R. C. and Kennedy, J. L. (Crown Mine Drainage Control Field Site, U.S. EPA), Natl. Coal Assoc./Bitum. Coal Res., Inc., Sixth Symp. Coal Mine Drainage Res., Louisville, Ky. (1976). 37 pp. The test facility constructed at the Crown Field site and the testing carried out there are described in detail. Previous work on lime and limestone treatment is summarized. The actual mine water used as feed for these tests contained moderately high amounts of iron, mainly in the ferrous state. Sludge recycle was incorporated into several tests. Effluent quality and sludge characteristics were monitored. Results indicated sludge and effluent characteristics comparable to those obtained with lime treatment and also indicated a cost advantage for combined treatment. OR 76-7

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